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ENGLISH AND AMERICAN LOCOMOTIVE-BUILDING.

By Charles Rous-Marten.

IT is not at all wonderful that a considerable sensation should have been caused by the publication of the fact that four English railway companies—three being of the first class—were ordering locomotives from American builders.

Some forty years have elapsed since a British railway company went abroad for engines. The last occasion, so far as I am aware, was about the year 1859, when MM. Schneider et Cie., of the Creusot Works, France, received a contract for building a number of single-driver express and four-coupled fast-goods-train engines for the Great Eastern Railway. Many of those engines were at work until a few years ago, and I believe all turned out well. That, however, was wholly a special occurrence, and even at the time it made some stir. Hopes were freely expressed that a British railway company would never again go outside Great Britain for its engines.

It has always been a tradition stoutly held in England that, if there be one thing more than another as to which Great Britain enjoys absolute supremacy, it is in railways and in the construction of locomotives. Other countries, it is admitted, may do well in these respects up to a certain point, but then it is found that there are counterbalancing drawbacks which leave the English products supreme in excellence. Naturally, then, it came like a thunderclap upon these patriotic spirits to learn that the Midland Railway Company had ordered twenty engines from the United States. When the news next oozed out that the order of twenty had been expanded to thirty; that the Great Northern had followed suit by ordering a batch of twenty; and that the

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Great Central had gone and done likewise, while, even the little Barry Company had added its small order to the big ones—then indeed a feeling of despondency almost approaching despair—a "glory departed" sort of sentiment—seemed to settle down over the land.

At any rate, that is the impression that might reasonably be obtained from a glance over the newspaper comments. And this state of feeling was even enhanced when the fact of the Atbara bridge contract also being obtained by America, became generally known. If England could not build locomotives for her own railways, or bridges for the territories conquered by her army, her case must indeed be a sorry one. Thus ran the prevalent course of comment.

A great deal of insufferable nonsense has been talked and written on the subject. I am bound to say that some of the English journals have been the chief offenders in this respect, the American papers, so far as has come under my notice, taking a far more rational and common-sense view of the case. It was alleged, for example, in one British paper, that the reason why American engines were ordered was that they are "much more powerful than English ones." I am certain that Americans will be the first to laugh at intolerable twaddle of this sort. To educated readers I need hardly say that power is virtually a question of dimensions and material. Tractive force is obtained by the same proportionate dimensions in America as in England. That there are differences in *design* is unquestionable. But this is due to the fact that the methods of the two nations differ widely, and so the respective designers aim at the attainment of different objects. This view, however, I shall expand farther on. It will be better that at the outset I should make quite clear *why* these engines, seventy in all for the three great companies, have been ordered from America at an aggregate cost of about £200,000.

Now, it is the practice of the large British companies to build for themselves as many as possible of their own engines. But in times of exceptional prosperity when traffic crowds upon them at a faster rate than they can conveniently dispose of it, the resources of their own works are overtaxed and they are obliged to go to private firms for the additional locomotives needed. In the present instance the great wave of improved trade and general prosperity which happily has swept over the British Islands during the past few years has brought about such a rapid and voluminous augmentation of traffic that in spite of the utmost activity at the Derby, Doncaster, and Gorton Works, the Midland, Great Northern, and Great Central Railways found it impossible to supply on the spot so many new engines

as were urgently needed. On the Midland, indeed, the existing goods engines, when they came into the shops for repairs, had to be turned out without being properly painted, a hasty coat of plain covering paint being all that time could be afforded to give them.

Thus it became necessary to seek the assistance of private builders; but, on application to the eminent firms that had previously supplied what was wanted in this way, all the three railways learned to their consternation that the press of orders was so great as utterly to preclude the acceptance of fresh contracts unless a year and a half or two years, or even more in some cases, could be allowed for fulfilment.

This was cold comfort to the traffic-overloaded railways. The need of additional engines was urgent and could not be postponed. Immediate recourse to other sources of supply was imperative. And so the contracts were entered into with Messrs. Burnham, Williams & Co., of the Baldwin Works, Philadelphia.

The engines ordered were in all these cases for the "goods" or "freight" traffic. They were required to be of an effective power equal to that possessed by the standard goods-engines in use on the three lines, of which drawings and dimensions were duly forwarded to Messrs. Burnham, Williams & Co. But the builders were authorised to construct them according to their ordinary practice, except for certain details to be mentioned later. That is to say, the goods-engines to be turned out at the Baldwin Works were to be freight-engines of the regular American type, modified only in respect of a few details. Messrs. Burnham, Williams & Co., having all their materials and parts and templates ready to hand, have been able to furnish the engines with a celerity that has seemed astonishing and almost incredible as compared with the customary way of British makers, and to unthinking or uneducated minds the contrast has suggested a number of conclusions, all transparently fallacious.

There have been many comments, for instance, on the strangeness of the fact that all the British builders should be thus overwhelmed with work just now. But this is the direct and obvious outcome of the engineers' strike of 1896. That most foolish and wrong-headed and mismanaged struggle cost both masters and men untold millions of direct loss, and sowed the seeds of consequential losses that operate now and must spread over many years still to come. One of the effects has been this present accumulation of arrears of work which has caused orders to the value of some £200,000 to be sent abroad, all of which is virtually kept out of the pockets of British workmen through their own insane action in the past. Again, it has been re-

VIEW IN MACHINE SHOP, BALDWIN LOCOMOTIVE WORKS. TOOLS DRIVEN BY INDEPENDENT ELECTRIC MOTORS.

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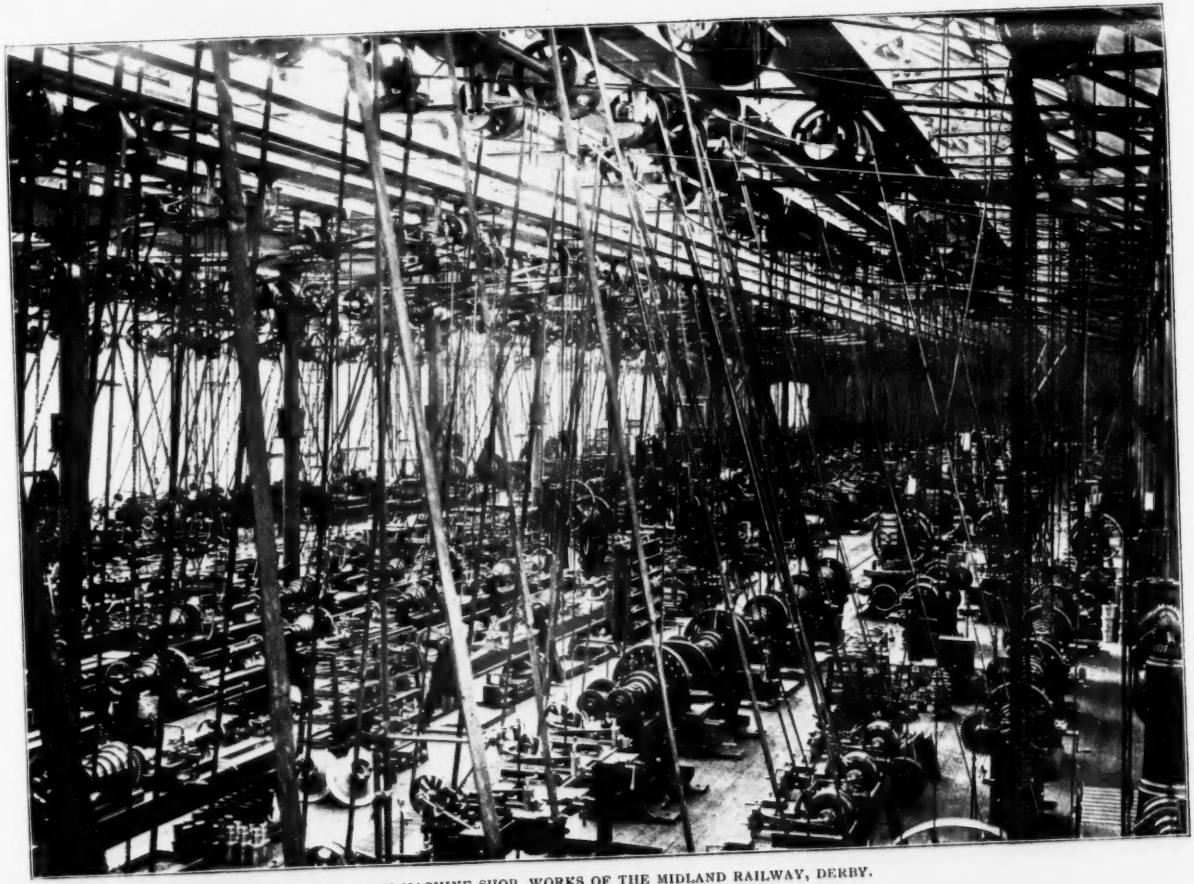


VIEW IN MACHINE SHOP, WORKS OF THE MIDLAND RAILWAY, DERBY.

marked as strange and blameworthy that the British makers should be less able than Americans to undertake an urgent order of this character at a moment's notice. This reflection arises simply from ignorance of the respective systems in force, a point to which I shall devote some subsequent attention.

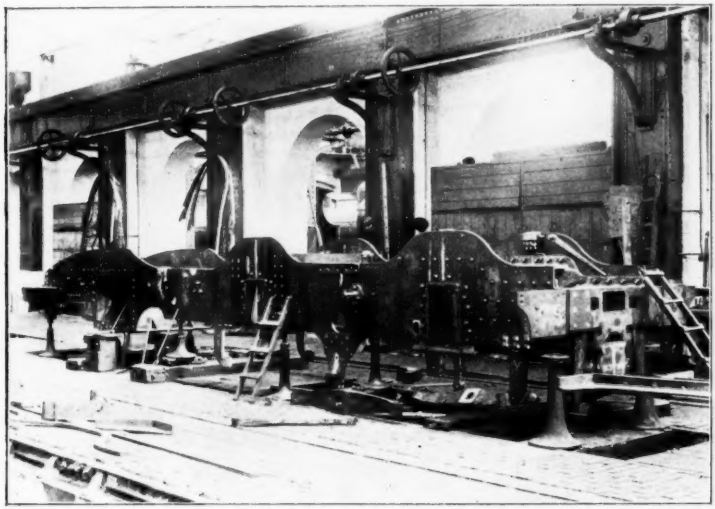
A third silly comment takes the form of a reflection upon the alleged blundering and lack of foresight exhibited by the English railway companies in not perceiving, a couple of years beforehand, what a sudden and heavy pressure of traffic would come upon them and what an accumulation of work would render British makers unable to provide the additional engines that would be required. It is difficult to treat seriously such a theory as this. It is of course put forth on behalf of the manufacturers, who have been accused of deficient enterprise exhibited in allowing America to secure these English contracts. Certainly it is not offered by any of the leading British engine-builders; for its absurdity is self-evident. No sane locomotive superintendent would move his locomotive committee to ask the directors for a vote of money to enable a large number of engines to be built or ordered in excess of present and prospective requirements, and if this were done, the shareholders would make it exceeding warm for the directors and officers at the next half-yearly meeting. The executive authorities of British railways endeavour, so far as may be, to adjust their appliances as exactly as possible to the requirements which have to be satisfied, and this rule applies not only to the number of locomotives ordered, but to the capacity of the engines themselves.

It is a reproach often brought against British railway engineers that their engines have no margin of power; that they are built to perform a certain duty, and that should the onerousness of that duty be increased, even in a small degree, the locomotive cannot perform it, but must have the assistance of a second engine, or "pilot."

Now at this stage I have arrived at one of the main *principles* which affect the present situation. Here we reach one salient point of difference between the methods of Great Britain and of the United States. The American locomotive engineer deems it advisable to design his engine with a very large margin of power. If an express engine is designed to take a 200-ton load at 50 miles an hour, and if that load should happen to be increased to 300 tons, the locomotive is still expected to be able to take it and keep time, and usually does so. Such, at any rate, is the experience of such an impartial and level-headed observer as Mr. W. M. Acworth. If an American

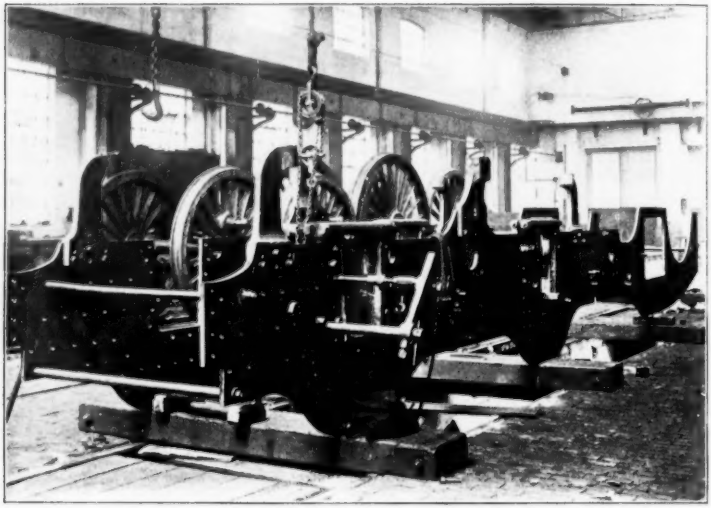
express be late at one point of its journey, the engine is expected to make up the lost time even if the load be larger than usual. And, again, this is generally done.

But if an English engine is given a single coach above its prescribed load, the driver at once insists upon having a "pilot," and commonly he gets one. Or should the weather be bad, with strong side-wind or a slippery rail, he demands an assisting engine and is accorded one, as a matter of course. Obviously this applies especially to the case of single-wheelers, which are so largely used on some English railways, because their range of power is much more sharply de-



LOCOMOTIVE IN COURSE OF ERECTION, L. & S. W. WORKS, NINE ELMS.

limited by adverse conditions than is the case with coupled engines. But in either case it seems indisputable that a smaller range of power is given to an English locomotive than to an American. It has long been a subject of criticism on the part of myself and other independent writers that the engines designed for some English lines are so manifestly deficient in respect of the power required as to render it a certain foregone conclusion that they will need extensive and frequent assistance by "pilots." When larger cylinders have been used, giving a great increase in the nominal tractive force, these have been coupled with a boiler no larger than that employed to fill the smaller



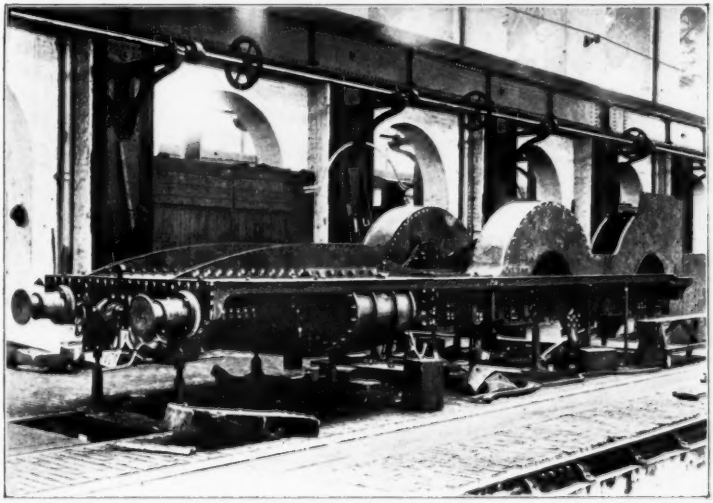
LOCOMOTIVE IN COURSE OF ERECTION, L. & S. W WORKS, NINE ELMS

cylinders, with the result that enough steam is not supplied to enable the larger cylinders to do their full work. Thus two classes of engine employed in fast and heavy express work have only 916 and 980 sq. ft. respectively of heating-surface. Another, with cylinders 19½ x 28, has only 1,031 sq. ft. In the United States, engines with similar cylinder dimensions and designed for similar duty, would have at the least, 1,800, 2,000 or 2,200 sq. ft. Nor is this difference explainable by the theory that a smaller heating-surface is, by more judicious disposal, made to do the duty of a larger area less favourably disposed, for the boilers referred to are small in all respects and assuredly have no margin whatever as a reserve to fall back upon in case of need.

It has been argued, in defense of this method, that there is no economy in building an engine which will not have its full power called upon during a considerable portion of the year, and that it is more economical to build an engine exactly suited to normal needs, which can be assisted by a pilot when loads are heavier or other conditions more unfavourable. It is not my present purpose to analyse the question or to discuss the merits of either side of the case. I simply desire to present a clear idea of the conditions which have to be satisfied in British locomotive designing. The engine has to fit its

known work. If a heavier train than normal should have to be hauled, the remedy adopted is either to divide the train or to employ a second engine.

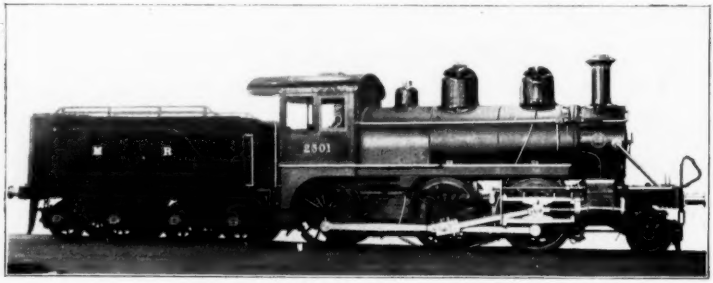
In appraising the force of this view it must of course be borne in mind that the conditions of railway work often differ largely between England and America. In the former country all the chief main lines have at least a double track and even a quadruple one. In America some of the most important lines are single-track roads. Obviously, in this latter case, the urgency of clearing the way with all possible speed is so great that it has to be a paramount consideration in designing a locomotive that it shall have such ample power as to reduce to a minimum the duplication or multiplication of trains. So we find that American engines, for express and freight service alike, are planned and built to exercise, in emergency, enormously greater power than would be available in the case of an ordinary British engine. In the latter case the limit of loads is conditioned further by station and siding accommodation. The late Mr. Patrick Stirling, on the Great Northern, and Mr. William Adams, when on the Great Eastern, both tried the experiment of building goods-engines of greatly-increased power, the former having cylinders 19 x 28 and the latter 19 x 26, with six 58-inch or 60-inch coupled wheels.



LOCOMOTIVE IN COURSE OF ERECTION, L. & S. W. WORKS, NINE ELMS.

But the types have not been perpetuated because, although the locomotives could haul far heavier trains, these trains could not be handled conveniently, and so nearly all the extra power and cost were wasted. Therefore the later engines built for freight service have, as a rule, only 17½ to 18-inch cylinders, and do all that is needed in existing circumstances.

Here then we perceive the folly of the allegation, made by certain English writers, that the new engines have been ordered from America because "American engines are more powerful than British." The new engines are not intended to be more powerful than the British locomotives with which they will work in regular turn. They have been ordered merely as equivalents. The English authorities build, as a rule, less powerful engines than do the Americans because they deem augmented power per locomotive unnecessary and regard the



BALDWIN ENGINE BUILT FOR THE MIDLAND RAILWAY.

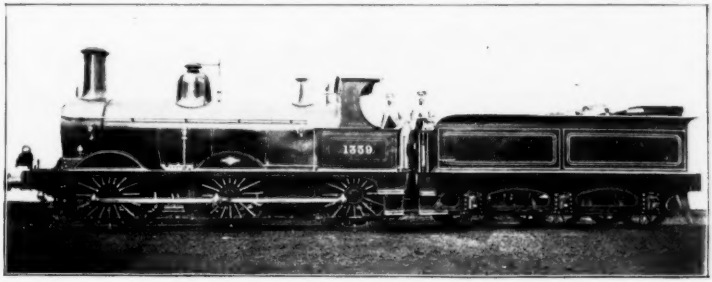
extra cost incurred in obtaining such augmented power largely in the nature of waste. In this view they may be right or wrong, but the fact nevertheless remains that the British engineers do not build more powerful locomotives "because they don't choose." It would be easy to do it but it is not thought expedient.

On the other hand, the advantages possessed by the American plan of having abundant boiler-power and a good margin of tractive strength seem to be coming more and more into recognition in Great Britain, so far as express work is concerned. All the most recent designs provide largely augmented boiler power and higher steam pressure. And it is tolerably certain that this tendency will continue and will increase rather than diminish.

There is, however, a condition which closely affects the designing of British express engines, as do the limitations of siding space

and hauling facilities that of freight locomotives. The awkward 4 ft. 8½-inch gauge cramps locomotive designers in America as well as in England. But in America the designer can spread outward beyond the rails almost as far as he pleases, and he can build upward to a height of 15 ft. 6 in. for the top of the smoke-stack above the rail-level. In England, however, lateral extension is sternly limited by the high platforms, and vertical extension by the heights of tunnels and bridges; so an English locomotive must not stand higher than 13 ft. 6 in. to the summit of its chimney. It is but just that this differing condition should be borne well in mind in appraising the relative features of British and American locomotive designs.

A further point of difference between British and American locomotive-building principles consists in what I may call the prognosis. "An American engine is at its best for only ten years and is an old

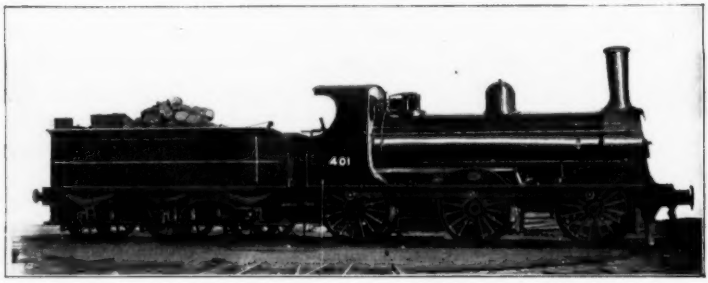


STANDARD GOODS ENGINE, MIDLAND RAILWAY.

(The type with which the Baldwin engines will work interchangeably.)

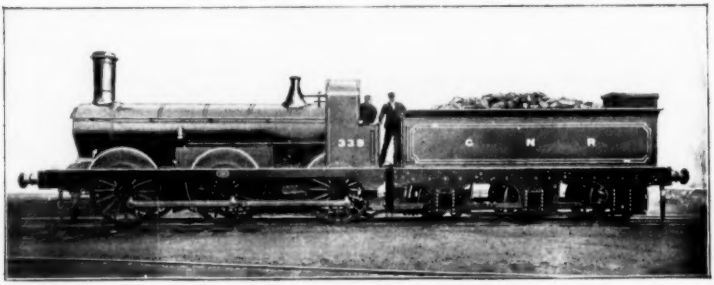
engine at fifteen years," said one eminent British engineer to me recently: "My engine will be good for thirty years or forty if required." On the other hand: "My engine will last for ten or fifteen years," said an American engineer to me, "and I wish it would not last so long, for it will be old-fashioned, if not obsolete in type, long before then."

Here you have, formulated in striking contrast, the two different principles. It has been remarked by a brilliant American writer that even the small bridges over ditches or tiny brooklets are built in England to last for centuries. The same idea pervades British locomotive designing. Curiously enough, the American principle of "doing things too well" in respect to power-provision prevails in Great Britain with regard to durability, the American practice being reversed. An express engine which was built so long ago as the year 1847 is at



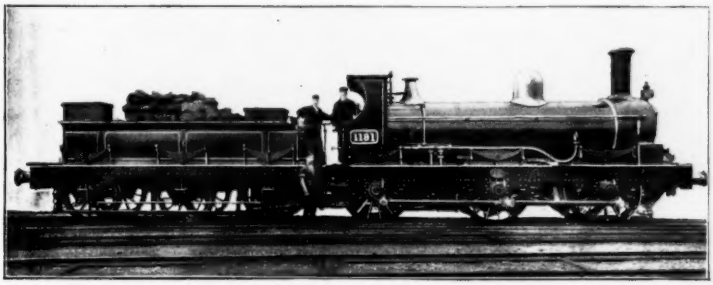
STANDARD GOODS ENGINE, LONDON AND SOUTHWESTERN RAILWAY.

this day working fast expresses in England. Numbers of engines built in the early sixties are yet at work and doing well. True, all have been repaired so extensively that they have become almost new machines. Still, I do not think I err in asserting that all would have been broken up and replaced by absolutely new engines fifteen or twenty or twenty-five years ago, in America. A slave owner is accredited with the saying that "It doesn't pay to take care of slaves and make them comfortable or to nurse them when ill; it is much cheaper to *use them up and buy new ones*!" That sentiment—atrocious in its application to sentient beings—is nevertheless one which may formulate a very sound policy in engineering. American policy is opposed to tinkering up antiquated and perhaps obsolete locomotives, in order to save the cost of new ones. English policy is opposed to throwing away engines which are still capable, when repaired, of doing useful service. Yet many a British locomotive superintendent devoutly wishes that some cataclysm of nature would sweep away finally all his old engines, thus leaving him free to bring in those having the



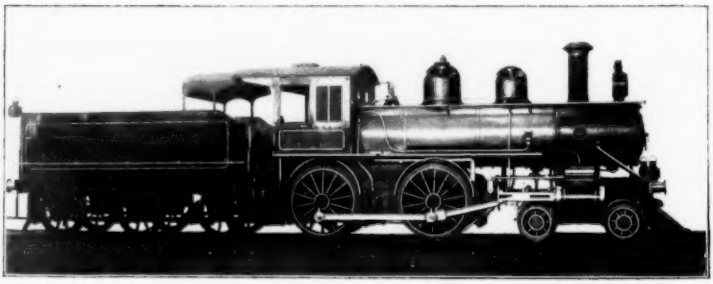
STANDARD GOODS ENGINE, GREAT NORTHERN RAILWAY.

modern improvements. Indeed, so strongly is the desirableness of this course felt by one eminent locomotive engineer— who, moreover, is famed for his economical administration—that he has sent to the scrap-heap nearly every engine of a date prior to his own advent some fifteen years ago. And the wisdom of the course is amp'y justified by the results. Yet his new engines are designed in their turn to last many years, and doubtless also in their turn to be voted obsolete at some future date. But the American tendency appears undoubtedly to build engines more cheaply, not intending them to last until they shall have become obsolete, or to outlive their day; also to get as much work as possible out of them while they do last—"use them up and buy new ones" is the theory, and it must be confessed that it has much to recommend it from a practical viewpoint.



STANDARD GOODS ENGINE, GREAT WESTERN RAILWAY.

It is, no doubt, imagined by some people, who unconsciously are tinged with the British idea, that engines constructed only to last ten or fifteen years must necessarily be defective—made of inferior material, or badly constructed—therefore must be less trustworthy than the more durable Britishers. But this is an error. Here again let me quote a British engineer: "The work in the American engines," he said to me a few days ago, "is good enough to serve its purpose and that is all. The builders know just what is absolutely needed and that is done, and no more. There is none of that extra finish and minute delicacy of work that we put into an English engine, and," he continued, after a moment's thought, "upon my soul I don't know why there should be, so long as the engines serve their purpose." And this, it is admitted, they do. But it at once becomes plain that this demand for excessive fineness of finish in detail is another respect in which the British makers are handicapped.



BALDWIN ENGINE BUILT FOR THE BENGAL CENTRAL RAILWAY.

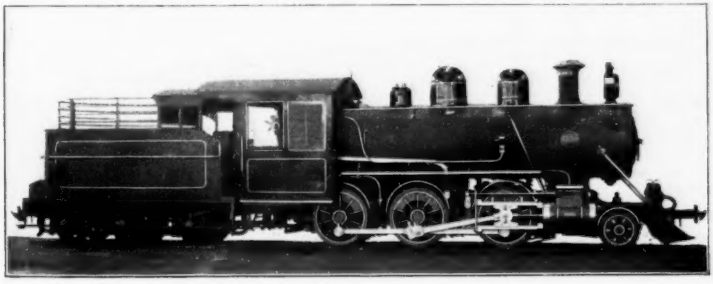
Neither can it be averred with absolute positiveness that the British method of making the boiler-tubes of brass or copper and the fire-box of copper, instead of both being steel, as in the United States, gives results commensurate with the cost involved. As to the superiority of these materials employed in Great Britain, there is, of course, no doubt whatever. The question is: Are they so much better as to be worth the additional expense? Much may be said on both sides, but probably the just view is that each fits in best with the national theory of construction. Nevertheless, the insistence on copper fire-boxes and brass upper tubes is unquestionably one marked difference between English and American methods and has to be taken into account in any attempt to estimate relative values. In the case of the present order, copper tubes and boxes were stipulated for by Mr. Johnson, and are being supplied accordingly.

At this point we arrive at another station on our journey. Having reviewed the salient considerations in locomotive *designing*, the next stage is to notice the difference in the British and American modes of locomotive *building*. It must be understood that in this instance I deal only with leading principles and salient features. Limitations of space necessarily preclude the possibility of my entering into minute items of detail. Also, it will be borne in mind that I refer solely to the private firms of engine-builders, and not to the locomotive workshops of the railway companies themselves.

I believe I am accurate in stating that the prevalent British method, in ordering a batch of engines from a private firm, is to stipulate that the engines shall have *a* dimensions, and *b* weight, and *c* steam pressure; shall be made of *d* materials, shall do *e* work, and shall be constructed according to the pattern *f*—each of the figures, etc., represented here by italic letters being minutely specified. Also, I un-

derstand that the usual American method is to stipulate that the engines shall do certain work and that the builders shall be held responsible for their doing it, but that otherwise the builders may construct the engines in accordance with their own patterns and style of build. That is to say, the two methods are in diametric opposition one to the other. In the English case the builders must build in strict accordance with elaborate specification down to the minutest detail, and sometimes are required to use materials or particular parts by some special maker whose name is specified. All this must be done, but still the engine as then built must fulfil all the prescribed requirements. And I am bound to add, in the great majority of cases it does so. In the United States the great principle of responsibility on the part of the contractor is carried to much greater lengths. "Build the engine as you please," he is virtually told, "so long as you supply us with an engine that will do the work stipulated." And here again, the result is usually entire efficiency.

It needs but few words however, to demonstrate in what a different position the manufacturer is placed by the two systems. In America it is worth a builder's while to provide and keep always on hand the various parts of engines of several different degrees of power, and all the templates, etc., secure in the certainty that there will be a demand for each, sooner or later. In Great Britain it would not pay a locomotive-builder to make these preparations, for he would not have the slightest reasonable certainty that any one of them would ever be of any use. Railway companies never order engines from private firms if they can help it. They infinitely prefer, for numerous reasons, to build their own. And so private engineering firms have no inducement to lay down costly plants and to provide expensive parts and materials. No doubt a few of the wealthiest and most



BALDWIN ENGINE BUILT FOR THE BURMA RAILWAYS.

famous British firms in this way of business, such as Neilson, Reid & Company; Dubs & Company; Beyer, Peacock & Company; Sharp, Stewart & Company—to mention a few of those best known—do hold themselves always in readiness for locomotive building, because they have always some work of this kind in hand for foreign or colonial customers. But even in these cases, only the machinery can be established *en permanence*, because if a British railway ordered any engines, the order would, to a dead certainty, involve the special making of each working part and also, probably, provision in the specification that some particular maker's tubes, etc., shall be used.

But when a "foreign" customer goes to an American builder and stipulates for an engine to be built of a certain power and delivered within a limited period, he is well aware that the American builder will say to him: "O yes; I'll build your engine and deliver it in the time named and it shall do what you require; only I am not going to be hampered by all these minute specifications as to makers, etc. Tell me what you want the engine to do and I'll guarantee it shall do it, but you must be content to have it according to one of the patterns which I have already in stock. Of course as to a few minor details I'll meet you, so far as I can, but if you desire an engine at that price and in that time you must take what we have."

Thus, the prevalent system does undoubtedly hamper British engine-builders in respect of colonial orders. The British colonies find it much simpler and more satisfactory to telegraph to Philadelphia, "Send us immediately twenty locomotives of class X in your catalogue," or "a locomotive that will take *a* tons up a grade of 1 in *b* at a speed of *c* miles an hour," than to prescribe every detail and take the risk of the result. I remember a case very much in point which occurred several years ago. A British colony ordered of an eminent English engineering firm twenty engines, ten express and ten goods, which were urgently needed and for which elaborate and minute specifications were forwarded. There happened then, as now, to be a press of work on, and if my memory be accurate the builders required eighteen months for the execution of the order. At last the first two were sent out, accompanied by the intimation that, through compliance with the other specifications, the engines were obliged to be made each ten tons heavier than the weight limit permissible.

Naturally this caused some consternation in the colony, as it involved such extensive strengthening of every bridge over which those engines had to pass as to amount to a virtual rebuilding. In the

correspondence which ensued it was made clear that the builders were not in fault for the error which had occurred. But meanwhile the shortage of locomotive-power had become a serious inconvenience and so, losing patience, the colony telegraphed urgently to an American firm to send out a dozen engines, express and freight, of the power and principal dimensions specified—*i. e.* of wheels, cylinders and weights. Those engines were landed within five months of the date on which the order was despatched, and cost £400 apiece less than the price of the British-built engines. They did all that was required of them and turned out satisfactorily in every respect.

Meanwhile the two British engines already sent out remained useless for a lengthened period, while negotiations were proceeding between the Colonial Government and the builders. In the end it was agreed, that the colony should accept the first two and undertake the alterations required to reduce their weight to a safe point, while the builders similarly altered the rest before shipping them. Whether the unfortunate locomotives that had to be thus cut and hacked about and whittled down "all over the shop," would turn out so well as their £400 cheaper American rivals may be left to the imagination of any educated reader.

I need hardly say that this experience resulted in an absolute cessation of orders from that colony to British builders. Strangely enough, while the influence of Imperialism and Diamond-Jubileeism was at its zenith, the same colony did endeavor to place a locomotive contract in Great Britain, but on learning that, owing to the pressure of orders, this one could not be executed for about a couple of years, the Colonial Government promptly transferred its custom to the United States.

Here then we see the respective conditions which prevail in Great Britain on the one hand and in America, on the other, as regards locomotive building. I have endeavored, as an entirely independent and impartial outsider, to present a strictly fair view of the case. If I have erred, it has been through inadvertence. I have refrained from expressing any opinion as to the relative merits of the rival systems and their fruits. Nor do I pretend to assert that the general rules of practice to which I have referred have no exceptions. But I have treated the situation as it is found to exist in ordinary experience.

In a future article I shall deal with a fresh phase of the question.

THE INCREASING PRODUCTION OF GOLD.

By H. M. Chance.

THAT the gold output of nearly every gold producing country has in recent years been rapidly increasing is well known, the total output of gold reported from all sources having, according to the best attainable figures, risen from an annual output in 1890 of $120,475,300 to $201,292,265 in 1895, and to about $286,218,954 in 1898. As the statistics of gold production in this and other countries are accessible in governmental publications, and as the newspaper, periodical and technical press also frequently furnish such information, by re-publication and otherwise, it is not proposed to discuss here the relative rates of increase in production in different parts of the world, nor to indicate the probable relative future importance of any particular districts.

In an article published in 1896 in the May number of this magazine, entitled "The Present Value and Purchasing Power of Gold," the writer indicated certain reasons why the large increase in output, now noted, should be anticipated, and invited attention to the consequences of increased production, accompanied by decreased cost of production, as sure to produce a corresponding decline in the purchasing power of gold which would be indicated by increasing prices for all commodities.

Apparently at that time the tide had not turned, and gold had much greater purchasing power than had marked its value for many years; but within the last two years the decline in its purchasing power has been marked by the rapidly advancing prices of other commodities.

In that article attention was directed to the fact that ultimately the value of all commodities must be measured by the cost of production, and, that, while improved modern mehods had effected large reductions in the cost of producing gold as well as of all other metals, gold had not declined in value, although other metals had so fallen; and that the prices of these other metals measured in gold units of value were abnormally low. Therefore a readjustment of values was to be anticipated, gold falling (or other metals rising) until each ruled in value at the average cost of production.

Some of the reasons why gold values respond sluggishly to re-

duced or increased cost of production were pointed out in that article and need not be repeated here.

It is the intent of the writer to take up the subject as it stood in the article of May, 1896, anticipating what has partially now been realized; to add to it the record of the last three years, to note certain new factors which have intruded and with which we must reckon in any attempt to forecast the future relative value of gold.

For a year past the financial world has been experiencing symptoms indicating rapid fall in the value of gold. These symptoms are, "easy money," "low interest rates," readiness to loan on collateral not formerly considered "gilt edged," and absence of any tendency to "hoard gold," willingness to subscribe to new bond issues, whether governmental or corporate, advancing prices for all classes of bonds and stocks and, most important of all, enhancing prices for nearly all commodities, for mineral, agricultural and manufactured products.

Politicians, and at times political economists, are prone to ascribe such changes to a "restoration of confidence," to peace, or to war, or to a "speculative craze," failing to recognize an underlying cause which impels such movements, producing the "confidence," producing the speculation.

And this cause, world-wide in its influence, making and unmaking values from generation to generation, producing great speculative opportunities to those capable of foreseeing them, is found in the fluctuations in the *cost of producing gold* and other commodities.

If the cost of producing wheat or iron or copper or wool is reduced by one-half, what is clearer than that the market price will fall correspondingly? So it is with gold also; but a decline in the value of gold is marked only by a corresponding increase in the market value of other commodities.

In the article above mentioned it was shown that the cost of producing iron, lead, zinc, copper and silver had declined largely in the preceding twenty years and that the purchasing power of these metals had declined from 44 to 52 per cent.; that the cost of producing tin had not been reduced as much as these other metals, and that its purchasing power had declined but 30 per cent. in the same period.

It was pointed out that the cost of producing gold from refractory ores had declined largely, but the cost of producing it by placer mining had declined very little; and as the world's store of gold had come principally from placer mining, and as the percentage of the total production coming from refractory ores had been small, that the

small stream of more cheaply produced gold from this source had not, up to that time, depressed the value of the large mass into which it was flowing; but that this gold of cheapened processes was rapidly coming to form a large percentage of the whole output and must inevitably bring the value of the accumulated supply to the level of the present cost of production by modern improved methods.

The writer believes we are now experiencing that change. How far it may go is difficult to foresee, but attention may profitably be given to some facts that will indicate whether it is likely to run its course quickly or slowly.

Whenever any industry becomes more profitable than others, many new workers are induced to engage in it, and as the great purchasing power of gold, co-existing with reduced cost of producing it, has in recent years made gold mining more profitable than most industries, large numbers of progressive men have become miners of and searchers after gold. Capitalists have been found ready to invest large sums in developing gold mining properties and in building the necessary mills and reduction works. The rapidly increasing production and the constant discovery of new mines and mining districts in all parts of the world are direct results of these conditions. That these factors will continue operative for a number of years seems probable, because such movements usually continue, by reason of the momentum gained, after the cause which set them in motion has ceased to act.

We may note further that, while in 1895 it was true that the cost of working placer gold "deposits had not materially been cheapened in the last twenty years," and that "the cost of producing gold from placer workings has remained practically unaltered by recent inventions," it is now necessary to modify these statements materially, because in the last three years it has been sufficiently demonstrated that many gold placers may be worked at low cost by steam power or electric dredges or shovels.

In almost every gold producing country are found gold placer deposits that cannot be worked by the ordinary methods of placer mining, but many of which may be cheaply and effectively worked by steam shovels or steam dredges. The successes recently achieved in working such deposits with these improved appliances bring within reach almost incalculable stores of gold, and from this source we may confidently expect a large and continually increasing addition to the world's output.

As capital, quick to find opportunities for profitable investment,

is already seeking dredging propositions in almost every country known to have river placer deposits, the gold produced by this method of working placers will doubtless soon become a factor of importance in the total yield.

During the last three years no further marked change has occurred in the cost of producing gold from refractory ores, but the limitations of the cyanide and chlorination processes have become better understood and their field of usefulness correspondingly enlarged, for both these processes are now so well known that it has become a simple matter to determine which of either process can be successfully used in treating any given ore; and this assurance, which the expert may now offer regarding these processes, often results in the speedy building of a mill which at once enters the ranks as a regular producer.

Three or four new processes, two of them electrolytic, are rapidly approaching the commercial stage and give promise of effecting further reductions in the cost of working refractory ores. If successful they will render large bodies of low-grade ores (worthless at present) available, which must add largely to the world's gold output.

The discovery of new gold districts and the development of new mines and deposits in old districts will probably be actively prosecuted for a number of years. Activity in this direction when once fairly inaugurated may generally be expected to continue for a considerable period.

From this source therefore we may look for large additions to the output of gold. New gold fields may and doubtless will be developed in British America, in Alaska, in Siberia, China, Africa, Australia, South America and various parts of the tropics; and new discoveries of importance in old mining districts, adding largely to the output, may be anticipated as long as the present active search for gold continues.

The production of gold may therefore be expected to increase steadily for a number of years from the following sources:

1. Enlargement of existing plants;

2. Discovery of new gold fields;

3. Discovery of new deposits in old districts;

4. Development of low-grade mines discovered in the past but unworked because of high cost, but now worked because of better and cheaper processes, cheaper materials and transportation;

5. Working of placer deposits with steam shovels and dredges;

6. Increased production of copper, lead and other ores carrying gold;

7. NOTE: The exhaustion of old mines is probably more than offset by the ability to mine cheaply at much greater depth.

While such a continuance of the present rapid increase in the production of gold appears probable as will carry the annual output of gold far above any figures or estimates yet made, no fears need be entertained that this flood of gold will cause a disastrous decline in its value or purchasing power, for it may always be confidently remembered that the value of gold, as of other products, is determined by the *cost of producing it*. In the last twenty years the cost of producing gold has fallen probably from 30 to 50 per cent., but, as the cost of producing most other metals and other staple commodities has similarly declined, the relative value of gold and other products has not suffered much change. Nor does such change appear probable, for there are no inventions or new conditions in sight promising any further large reduction in the cost of producing gold that would not similarly affect the cost of producing other staple commodities.

As suggested in the article before mentioned, in 1896 the prices of iron, copper, tin, lead and zinc were abnormally low; the purchasing power of gold abnormally high. A readjustment has occurred: lead, zinc, tin, iron and copper have rapidly risen in price, and on all sides one hears expressions of opinions indicating a general belief that this rise in value is abnormal; that it is due to artificial and not to natural conditions, and that while a moderate advance in the price of metals was justified by the economic and governmental conditions of this country, that the increase in price is greater than these conditions would naturally effect. And supplementing opinions of this nature is the very common belief that present prices cannot be maintained for any considerable period. Those reasoning in this way base their belief upon a conviction that the rise in metal values is due principally to "restored confidence" in the future of this country, to a period of activity with increased consumption naturally following the period of depression through which we have passed, and to a natural reaction from what were generally recognized as abnormally low prices; *i. e.*, prices actually below the cost of production or too near the cost of production to afford a living profit.

This line of reasoning largely ignores the fact that the advance in values reaches far beyond the limits of this country, is world-wide in fact, and therefore cannot be attributed to restored confidence in the future stability of the government of this country.

While restored confidence with corresponding increase in consumption of metals for structural purposes has doubtless hastened the readjustment of values, it does not seem possible that such large and general advances in market prices could have occurred except by reason of the flood of cheaply mined gold which is being added to the world's store.

The great speculation in copper mining stocks and in copper mining properties is eliciting much discussion, and many fear disastrous results from the collapse or reaction which they regard as inevitable. If the position here taken is correct no such result need be feared regarding the successful dividend-paying copper properties, although unwise inflation of the values of unproductive properties—of mere "prospects"—is always to be deplored. For, as compared with gold, copper should certainly be intrinsically worth 15 to 18 cents per pound as measured by the relative cost of producing the two metals notwithstanding the fact that 10 or 11 cents has been the ruling price for several years. The writer would draw the same general inference with reference to other metals, and believes that the continuance of the increase in the output of gold will justify the maintenance of prices from 50 to 75 per cent. higher than the abnormally low prices reached during the recent period of depression.

With advancing civilization, extending, by sword and cross, rapidly year by year over those countries inhabited by the barbarous or semi-civilized nations, must come rapid increase in the consumption of and demand for all metals. This alone may be a strong factor in the maintenance of prices for all metals, but, more important still, a large percentage of copper, lead and silver ores carry also notable quantities of gold, so that any large increase in the output of these metals must add largely to the annual production of gold. The increase from this, source, therefore, promises steady future growth, irrespective of that due to increased activity in gold mining proper.

The opening of the Trans-Siberian railway, the completion of the great North and South road through Africa, and the industrial development and railroad building in South America, open to civilization vast regions in which gold may be found and which ultimately must be the scene of extensive mining operations. English and French capitalists have already engaged American experts to examine the Siberian provinces for promising gold deposits in anticipation of the possibility of profitable mining when cheap transportation is assured. Russians, Frenchmen and Americans are now exploring the Northeastern Siberian provinces and report extensive areas of

gold bearing territory. Peru, Bolivia, the U. S. of Colombia and Brazil are being scoured by hundreds of English and American prospectors and investors for gold mines; Western Australia is likewise being searched from shore to shore, and in South Africa the prospecting of new regions never ceases. These added to the Arctic fields (the climate of which the miner no longer fears) promise an immediate and continuing increase to the present large annual output of gold. In almost every district old mines are increasing their output, and formerly abandoned or unworked mines are becoming regular producers.

Another reason for anticipating further increase in the production of gold is found in our better knowledge of gold ores, and of the conditions under which gold occurs in nature. Until the discovery of the Cripple Creek district, the occurrence of gold as tellurid in deposits of large extent and value was practically unknown. Gold was, of course, known to occur, sparingly in some ores, partially as a tellurid associated with other minerals; but such a mineralized belt as that at Cripple Creek was entirely unknown, and such deposits were not looked for by the prospector.

Similarly, we now know of another class of gold ores in which the gold occurs apparently in some form chemically combined in a silicious matrix, often approaching a true jasper or hornstone, and showing by analysis possibly 95 per cent. of silica. Such ores show no trace of "free" or metallic gold, and the presence of gold can be determined only by assay or analysis. A few such discoveries have recently been made, accidentally, by inexperienced persons who had rock assayed from curiosity.

Similarly again, in the last few years, gold has been found in most unpromising looking porphyry dykes—the very rocks prospectors the world over have regarded as necessarily barren because they almost invariably fail to show any "free" or metallic gold by the miner's quick "horn" or "pan" test.

But mining engineers and prospectors are learning that in a mineralized region gold may occur in any rock, and hundreds of prospectors are assaying all sorts of most unpromising looking rock, satisfied that by assay alone can they determine whether a certain rock is gold bearing or not.

This persistent and more or less systematic work now going on in every mining district must result in the discovery of many valuable deposits in unexpected localities, and ultimately promises to add largely to the annual output of gold.

THE WORK OF THE NAVAL REPAIR SHIP VULCAN.

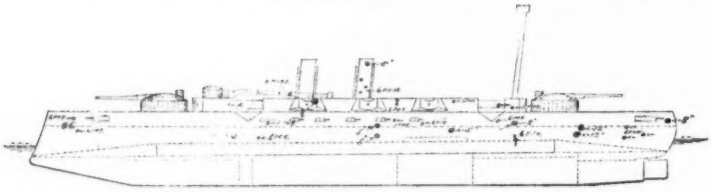
By Gardner C. Sims and Wm. S. Aldrich.

WHEN Admiral Sampson left Guantanamo Bay, 10 A. M., Sunday, August 14th, 1898, almost immediately after the signing of the protocol, and sailed north with the battleships, the first work of the mission of the *Vulcan* as a naval repair ship had been fulfilled. The efficiency of the fleet in Cuban waters had been maintained. The vessels of the Eastern Squadron for a naval demonstration off the coast of Spain had been fitted out and repaired in foreign waters, in a time of war, without recourse to a navy yard. The remaining work ahead consisted of minor and miscellaneous repairs, changes, alterations, etc., of vessels of the auxiliary navy and a few of the regular service making Guantanamo Bay a naval base. This was to be followed, after their being raised and floated, by overhauling, repairing and fitting out the former Spanish vessels, the *Sandoval* and the *Infanta Maria Teresa*. In this interval the character of the *Vulcan's* repair work was radically different from that executed before the protocol. It now partook of the nature of regular navy yard work, in times of peace, with much more of routine fitting out work than that considered necessary for the well-being of a fleet in war time.

The former Spanish gunboat *Sandoval* had been scuttled and sunk in the head waters of Guantanamo Bay, off Caimanera, by her treacherous Spanish captain, to prevent her falling into the hands of the Americans. On Sept. 1, the *U. S. S. Marblehead* and *U. S. S. Potomac* succeeded in raising the *Sandoval*, and the following day she was brought alongside the *Vulcan* for overhauling, repairing and fitting out. The same evidence of Spanish treachery and vandalism was to be seen in this little 100-ton gunboat, as in the case of the *Cristobal Colon* and the *Reina Mercedes*. Sea valves were opened, dead lights were broken in, and on every hand was ample evidence of an attempt to so injure the vessel that, should it be raised, it would be of little use to anyone. The copper feed pipe which had been battered and cut by an axe, was repaired on the *Vulcan*.

Aside from the work for the steam engineering department of this vessel, a very large amount of work was executed for the equipment

and the construction departments. The engine-room telegraph was overhauled, the whole motive-power machinery of the 137 horse-power triple-expansion engines was taken apart, cleaned, repaired and put into service; boilers were overhauled and repaired; and weak and corroded side plates forward were replaced by new ones, after the *Sandoval* had been beached on the shore by the Playa del Este. We



INFANTA MARIA TERESA
(Showing approximate locations of hits and probable sizes of projectiles.)

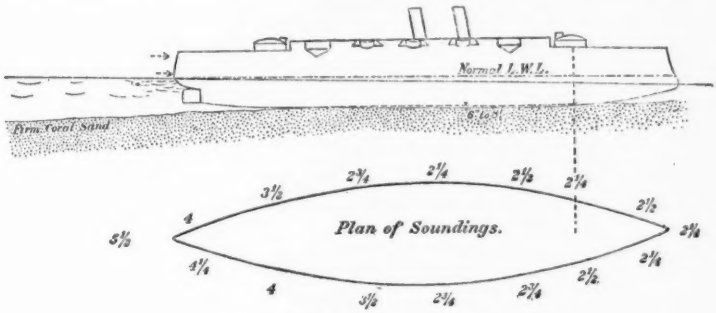
were confronted with the English or Whitworth system of threads in all cases of repair work executed for the Spanish vessels, as well as for the English-built vessels like the refrigerating ship *Glacier.*

The Spanish armored cruiser *Infanta Maria Teresa* was constructed in the works of the Martinez-Rivas Palmer Co., at Bilboa, Spain, in 1890-91. These works were operated under the control of the Spanish government, after their failure, and placed under the personal supervision and directorship of Admiral Cervera. This vessel, the sister ship of the *Almirante Oquendo* and the *Vizcaya,* was 364 feet long over all, of 65 feet beam and 38 feet depth of hold, of 7,000 tons displacement and a mean draft of 21 feet 6 inches. She was protected at the water level by a 12-inch armor belt, on each side, extending 315 feet and rising 5.5 feet vertically, with 12 inches of armor around the conning towers, 8 inches of armor around the ammunition tubes, and from two to three inches of protective decks. There were two 11-inch Hontoria guns, one each in forward and after turrets, mounted *en barbette,* under 2.75-inch spherical canopy and behind nine inches of armor plate. Five 5.5-inch rapid-firing Hontoria guns were mounted on each broadside within the citadel, with twenty other guns of various calibres. There were eight torpedo tubes in all.

The twin-screw cruiser *Infanta Maria Teresa,* on her trial trip made 18.5 knots per hour on natural draft, developing 9,560 indicated horse power. On the forced-draft trial trip she made 20.2 knots per hour, developing 13,760 indicated horse power. Her coal capacity was 1,050 tons, giving a steaming distance of 9,000 miles at a ten-knot

speed. The full complement was 484 officers and men. Throughout the whole of this ship there was installed the latest and most approved complete system of voice-pipe arrangements. Chadburn's patent telgraph signalling system had also been installed, as in our own naval vessels. Admiral Cervera having personally supervised every detail of construction of this fine armored cruiser, there is no wonder that when he made his famous sortie from the harbor of Santiago he selected this vessel as his flagship instead of the Italian-built armored cruiser, the *Cristobal Colon.*

At 9:35 A. M., in the morning of July 3, the *Infanta Maria Teresa* steamed out of the harbor of Santiago at about a 10-knot speed; and five minutes later, at about 4,000 yards range, actively engaged the American vessels. At 10:15 she was seen to be on fire, and heading for the beach, the firing from her guns having ceased. The early destruction of all of the most approved means of communication and the blocking up of all passage-ways by the rapidly-spreading flames made it impossible to command further the movements of the ship as a fighting machine. Forty-five minutes to silence and throw out of action a most modern war vessel, furnishes precedent for the

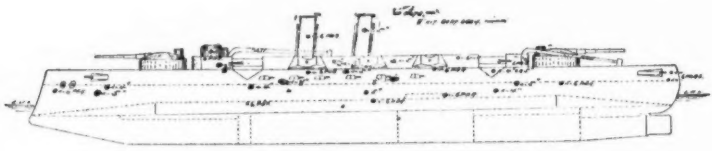


INFANTA MARIA TERESA AS BEACHED.
(Soundings in fathoms)

conduct of naval warfare which Admiral Colomb of the British Navy speaks of as being "terribly business-like on the American side."

Admiral Cervera, in his report to the Spanish Minister of Marine, states: "There could be no doubt as to the outcome, but I should never have believed that our ships would be destroyed so rapidly." He then shows that the first shells which the *Maria Teresa* received resulted in the bursting of an auxiliary steam pipe and of the water mains, the enemy's fire producing terrible injuries, and destroying the

chief elements of defense as well as the net for protection against fire. The explosion of another shell set fire to his compartments, which spread with great rapidity, and was joined by other fires, the result of similar shell explosions. Sufficient water could not be obtained to keep the flames under control. Orders were given to open the valves in the after part of the ship to flood the magazines but it was impossible to do so. Dense clouds of smoke prevented passage through the ship below deck, and Cervera's instructions could not be carried out. "In this situation," he states, "I could only think of beaching the ship, and did so. The contest was impossible on our side. I thought to lower the flag, but that was not possible on account of the fire, which prevented all operations." She was headed for the beach, west of



VIZCAYA.

(Showing approximate locations of hits and probable sizes of projectiles.)

the Punta Cabrera, only six miles from Santiago harbor, and stranded at the same moment that the engines stopped.

From an examination of the wreck it is evident that about the *Infanta Maria Teresa* the fire of the American ships began to concentrate with most telling effects. The vessel was hit about thirty-three times, above the exposed waterline. An 8-inch shell struck the shield of the second 5.5-inch gun on the port broadside, passed through, ranged aft, and exploded with terrific effects. Another 8-inch shell struck the gun deck, under the after barbette, passed through and exploded, ranging aft, tearing and ripping the beams in its path, and greatly damaging the longitudinal bulkhead between the two cabins, and cutting the fire mains. Two 12-inch shells entered just under the berth deck, through almost the same hole, "keyholing," as it is called, exploded in the stern torpedo room, cut the berth deck beams from the frame, completely wrecked everything in that compartment, and opened up a large ragged hole, about four feet square, on the starboard side. A 5-inch shell struck under the berth deck, ranged aft, passed through wing passage into coal bunker and exploded, setting fire to the coal.

Of all the wrecks the *Maria Teresa* had been the least damaged

above the water line. Torpedoes were found intact and magazines uninjured. Only the forward military mast and its fighting top came down with the weakening of its substructure, due to the intense heat of the fire in the fore part of the ship. It fell aft into the starboard gangway. The wooden bulkheads above the protective deck, the wooden deck-flat, and almost every vestige of wood above the water line was destroyed by fire. Admiral Sampson speaking of this feature states: "If the war teaches one lesson more than another it is to dispense with all wood in the future construction of our ships. Not a particle of it should be permitted where it is possible to avoid it."

The board appointed by Admiral Sampson to examine the condition of the Spanish vessels, sunk or destroyed, reported on July 13, 1898, after an examination made as complete as possible along the following lines: condition of hull and the practicability of saving the vessels; condition of ordnance equipment, magazines, etc.; condition of machinery and boilers; effect of gun fire upon the enemy's vessels. From this valuable report the following details are taken, of particular interest with relation to the *Maria Teresa:*

The vessel was found nearly upright, lying without appreciable angle of heel at a water line differing from the load water line by trimming about five feet by the stern. Flooding was practically complete fore and aft. The vessel rested easy, bearing upon the bottom throughout the greater part of her length. Soundings showed the bottom to be firm coral sand, shelving gently more or less. Diving within the hull was impracticable under the conditions.

The frames above water were practically intact, having only deformation more or less moderate, due to heat. The deck beams above water were generally more or less warped by the heat. They had sagged and dropped to such an extent as to destroy their structural usefulness. The stanchions had been affected in practically the same manner as the beams. The bulkheads above the protective deck were principally of wood. Those of metal—limiting the upper coal bunkers —were badly warped.

Generally speaking, the outside plating for structural purposes was considered intact. There was warping, though not pronounced, in the upper portions subjected to heat. Divers' reports showed an intact condition below the water as far as examination could be extended. All deck plating above the protective deck, including the stringers and tie plates, had been more or less warped and the fastenings impaired by the heat from the burning of the wooden deck-flat.

Taking full account of the distribution of weights and strains in-

volved, and of the reduction of strength as pointed out, it was in general considered that with an intact condition of internal structure below the protective deck the remaining structural solidity was adequate for the stresses liable to be encountered in wrecking the vessel or in any except severe conditions of navigation. Occasion was taken to point out that the vessel had suffered more as a longitudinal girder than as a transverse girder, and that in a heavy sea it would be on the side of security to avoid the position of steaming head to sea. There were no indications of any internal explosions having occurred on this vessel. All deformations found could be readily accounted for by the heat effect of the conflagration.

The engines were found covered with water to within six inches of the tops of the cylinders. From what could be seen it would appear that exploding shells had not struck them. There was no evidence in the approaches to fire rooms of any boiler explosions having taken place. The boilers, however, were subjected to extreme strains, due to sudden cooling. All the piping above the protective deck had been warped, melted and otherwise destroyed by heat.

The structural solidity of the ship was not to any considerable degree injured. Barring local distortions, the hull was found practically intact. The outside skin was reported by divers as intact so far as holes were concerned. The examination extended to the bilges, fore and aft, and, in some parts of the extremities, to the bottom The board was therefore of the opinion that it was possible and desirable to float the *Infanta Maria Teresa*. The vessel lay in a very good position, with deep water astern to facilitate pulling her off, and fairly well protected against an easterly sea.

In order to lighten the *Maria Teresa* as much as possible, the wrecking company cleared out all store-rooms, lockers and compartments; removed the ten 5.5-inch guns, shields, etc., which were mounted, five on each broadside; removed the fourteen torpedoes and war heads, anchors and chains; and by direction of the commanding officer in charge, large quantities of foul, decayed and unhealthy stores were thrown overboard, with unsafe ammunition which had been condemned.

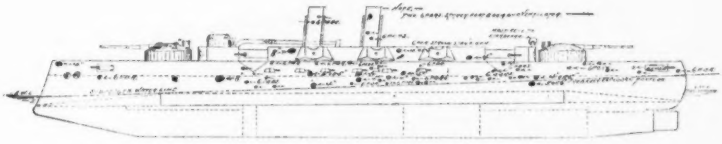
An attempt to float the *Maria Teresa* was made about the middle of August. It was to be by the so-called "quick-dispatch" method, consisting in closing all accessible holes, putting in enough pumps to control the leaks, hauling off, and towing to the nearest port for docking and repairs.

An unexpected influx of water occurred, having entered through

the leaks forward, and worked aft through a large number of openings, many of which were then unknown to the wreckers. Following this the water had risen inside to a level only slightly lower than outside. But it was considered safe to allow this water to remain till the large leaks forward could be located and gotten under control.

The method then followed was to locate and stop the leaks, largely from the inside. All efforts which had been made to stop the leaks from the outside had proven futile, the blankets, canvas, etc., being either carried away by the swell or sucked completely inside the ship. The approximate position of the leaks was determined and large pumps were concentrated on those compartments, while divers were kept steadily at work on the leaks. Four large pumps were kept ready for duty, being supplied by steam from the two donkey boilers of the *Teresa,* and from four portable donkey boilers put aboard by the wreckers.

Again, everything appeared to be in readiness for floating the *Teresa.* The first visit made to the wreck, Sept. 19, which found the



OQUENDO.

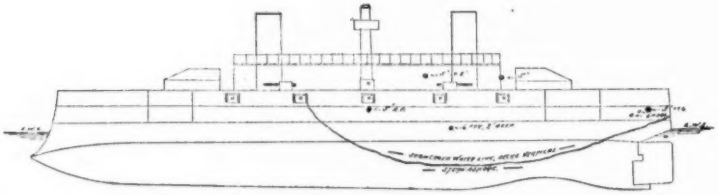
(Showing approximate locations of hits and probable sizes of projectiles.)

Vulcan lying to, in the heavy ground swell off the site of the wreck, by the shore of Minamina, with an engine room temperature at 110 degrees, and that of the fire-room at 140 degrees. The attempt to float the *Teresa* at this time, however, was not wholly successful. It had to be again postponed. It was evident that the wreck could be floated and taken in tow, but it was not deemed advisable to do so at that time. The *Teresa* had been practically floated and the ultimate success was now beyond question. There was a slight movement, with more or less swaying of the stem, but the wreck seemed still to be down by the head, and to require greater buoyancy at that point to place it on a more even keel.

At the same time the *Vulcan* placed a working party of chief machinists and helpers aboard the *Teresa,* with all necessary tools and supplies, to put the steering engine and gear in order, and do such other work as might be found necessary, preliminary to tak-

ing the wreck in tow, for Guantanamo Bay. This party remained on board till the *Vulcan* again visited the *Teresa.*

A second visit to the scene of the wreck was made on September 23rd. At 9:50 A. M., the *Infanta Maria Teresa* was successfully hauled off the beach amid the firing of national salutes and the blowing of steam whistles from all directions. She was taken in tow by the *U. S. S. Potomac* and the wrecking tug *I. J. Merritt,* with hawsers from the starboard and port bows, respectively. The flagship *Newark* and the repair ship *Vulcan* stood off close on the starboard and port quarters of the wreck, respectively. The former Spanish gun boat *Alvarado* and the wrecking tug *Chapman* followed on the starboard quarter, while the wrecking company's supply ship *Signor* and



CRISTOBAL COLON.

lighter followed off on the port quarter. The *U. S. S. Scorpion* stood off the tow and well in shore in order to indicate the location of selected beaches had such an emergency arisen as would make it necessary to beach the *Teresa.*

During the tow of the *Maria Teresa* to Guantanamo Bay the sea was quite calm for a while and all went well. After passing Morro Castle, at noon, a breeze sprang up, stiffening somewhat later on, bringing with it rain and heavy winds, making our progress very slow and somewhat hazardous. At times there seemed great probability that the *Teresa* might again be lost. Owing to the direction of the storm it was necessary to stand well off the shore The *Teresa* would shear off alternately to port and to starboard and become almost unmanageable. Old-time sailors attributed all of this to the unlucky day of the week, the Friday selected for this work. Landsmen said that Cervera's pet cat on the *Teresa* was guying his pet dog on the *Vulcan.*

The *Vulcan* and the wrecking tug *Chapman* stood close by off the *Teresa's* quarters ready to run a hawser forward if necessary to steady the ship and assist in keeping the *Teresa* on her course. This was not done, however, notwithstanding the hazardous condition in which the

towing vessels *Potomac* and *Merritt* were very frequently placed owing to their short bow line hawsers. Guantanamo Bay was reached at 7:30 in the evening, and at 9:30 we came to a safe landlocked quiet anchorage far inside the offing, thenceforth to be known as "Teresa Bay." An earlier survey of this admirable anchorage had been made by the *U. S. S. Newark* and such a spot selected for the berth of the *Teresa* as would place her keel within easy reach of the divers when standing on the bottom of firm coral sand.

When the *Maria Teresa* had been safely anchored in Guantanamo Bay, a thorough examination was made, and Lieutenant-Commander Ira Harris, U. S. N., commanding officer of the *Vulcan*, reported on her condition as follows:

"Captain Chittenden, the wreck master in charge of the work for the wrecking company, agreed with me, as soon as a careful examination had been made, in considering five things as essential for reasonable safety in a passage from here to Norfolk:

"First. The holes in the bottom are all located in a space of about seven feet square, and should be secured by a patch on the outside, a cofferdam inside, and by making that compartment water-tight.

"Second. The main engines should be put in condition to steam in case of towline parting.

"Third. A spar deck strong enough to throw off any seas should be built between the two iron bulkheads on the bow and stern, the two bulkheads should be made tight, and all openings in the iron decks outside these bulkheads closed.

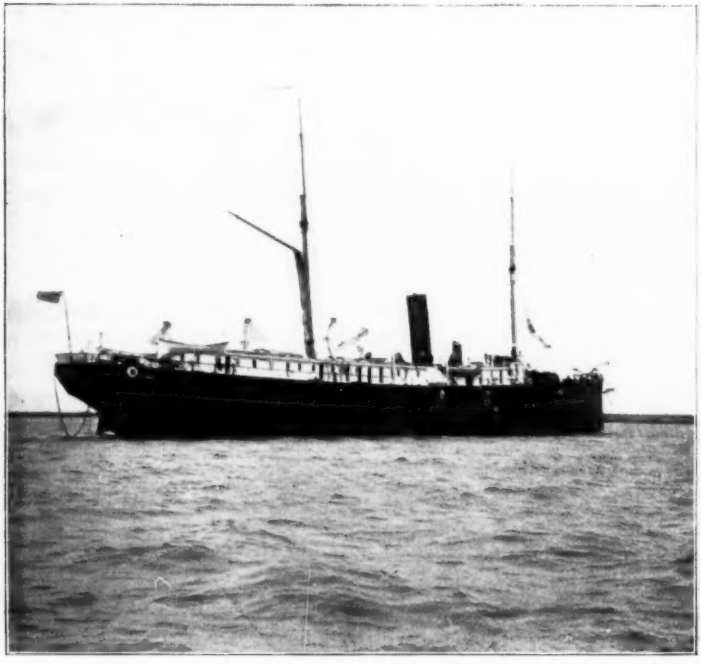
"Fourth. Sufficient control should be had of the pumping and drainage systems so that the safety of the ship should not depend on the wrecking pumps alone.

"Fifth. That the shot holes, broken parts, and other openings in the sides should be safely closed."

A camp was at once established by the shores of "Teresa Bay" for the hundred or more Cubans to be employed on the wreck. These men were secured from Caimanera, Guantanamo and vicinity, quartered at the camp, provided with rations from the *Vulcan* and other United States vessels, daily mustered and sent aboard the *Teresa* in charge of their own foreman. As large a detail as possible was made from the *Vulcan's* best workmen of all classes, and daily engaged in overhauling, repairing and fitting out the *Teresa*. An expense account of labor and material was kept for all work done on the wreck. An accurate daily log or journal of each day's work was written up, containing the number of hours of work of each man employed, his navy

rating and pay, the number of men employed, kind of work done, with a complete and accurate list of all stores or other articles supplied the *Teresa* from the *Vulcan*.

All efforts were exerted to make the ship thoroughly sea-worthy and the main engines and boilers serviceable with such work upon them as is usually found necessary to overhaul and repair submerged machinery. Brass castings were made to replace broken parts and for new gear, light and heavy forgings were executed and a great number of boiler plates were gotten out to cover the shot holes and other leaks in the outside plating. The dynamos of the *Teresa* were thoroughly



U. S. S. VULCAN AT SEA

The Vulcan is a single-screw steamer, 265 feet long, 40 feet breadth of beam, 26 feet depth of hold, with a load draft of 17 feet forward and 20½ feet aft, and a carrying capacity of 2,700 gross tons. The main engines are of the vertical inverted cross-compound condensing type, cylinders 40 and 72 inches diameter by 48 inch stroke with four main boilers, one auxiliary boiler, and a surface condenser with independent circulating pump. At 80 pounds' boiler pressure, and from 55 to 60 revolutions a minute, she attains a twelve-knot speed on a coal consumption of 25 tons daily.

examined and found to be utterly useless owing to grounds everywhere. The importance of light on the wreck is apparent during both its overhauling and convoying north.

The progress of the *Vulcan's* work in overhauling and repairing the *Maria Teresa* had so far progressed by Oct. 12th, that Lieutenant-Commander Harris reported of it as follows:

"(1) The outside patch is safely secured and so skillfully that the bow has raised 70 centimeters. To get at the space where the coffer-dam must be made it is necessary to cut through the floor of the sail room, remove the sand, which to the amount of perhaps 60 tons has entered there, and cement and concrete several large breaks and bends. It is slow work removing the sand, which cannot be pumped and has to be carried by chains of Cubans with buckets.

"(2) The starboard main engine has been reversed this day by steam and will be worked in perhaps two days by steam. The port engine is perhaps four days behind.

"(3) The deck is nearly done. The after part is being roofed in for quarters. Bulkheads will be put in. Part of the bridge has been restored; a steering wheel put there, the steering engine put in running order, speaking tubes put in to the steering engine and to both main engines, and electric bells to call the engineers to the speaking tubes. A deck has been put over the iron deck forward to work the ship from.

"(4) The drainage of the ship is so complicated and has been so injured by fire and shells that it is difficult to follow out and control. The pumps now are nearly all in working condition, and by trial we are gradually finding what we need.

"(5) In addition to the shell holes and ports of all kinds, we have in the last day or two discovered that four torpedo openings were in a very dangerous condition. The gates had been so hot as to char the wood outside of them into mere charcoal, which fell from the bolts at a touch. Patches have to be riveted over all these holes."

At sea, Tuesday, Nov. 1st, 1898, at 5:11 P. M., Lat. 24° 33′ North, Long. 74° 35′ West, about 45 miles N. N. W. from Watlings Island, the Spanish armored cruiser *Infanta Maria Teresa* was abandoned while in tow of the *U. S. S. Vulcan* and the Merritt-Chapman Wrecking Company's steamer *L. J. Merritt*, bound from Guantanamo Bay, Cuba, to Norfolk, Va., under contract with the wrecking company for safe delivery of the wreck at Norfolk for the sum of $100,000. No lives were lost, all hands having been successfully transferred to the *Merritt*. The wreck was abandoned

with 16 feet of water in its hold, and supposed to be in a bad condition.

At 5:30 P. M., Saturday, October 29th, the *Vulcan*, having the *Infanta Maria Teresa* in tow, and with the *Merritt* assisting ahead, started to leave Guantanamo Bay. Owing to the length of the towing hawsers and size and difficulty of handling the wreck, it was 7:10 P. M. before we left the harbor and started ahead full speed. The *Merritt*, with 200 fathoms of 10-inch manila line fast to head bitts on the *Vulcan's* forward deck, led the tow. The *Vulcan* in turn was towing the *Teresa* with 230 fathoms of 15-inch manila line, made fast to a chain bridle which was secured to the bitts on each quarter and barked to the bitts in either gangway. The *U. S. S. Cincinnati* and *U. S. S. Leonidas* accompanied the tow, as convoys, taking position on either quarter of the wreck. The weather this night was fair, but bad weather was threatening, the moon being almost obscured by a thick mist. The barometer ranged from 30.05 to 30.09. All three ships behaved well in the head sea caused by the trade winds and made an average speed of six knots.

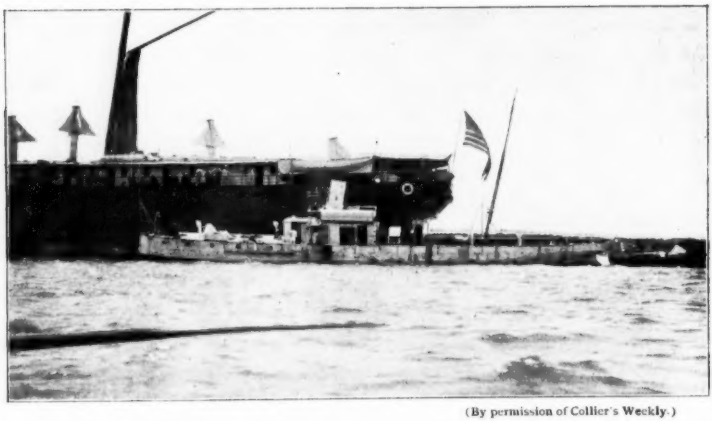
At 8:12 A. M., Sunday, Oct. 30th, Cape Maysi bore abeam, distant about three miles. Soon after, at 8:50 A. M., the *Cincinnati* left, making international signal, "A pleasant passage." All during the day the tow proceeded without difficulty towards Crooked Island Passage. The trade winds were fresh and the sea moderate, but the weather was damp, misty and cloudy, making sights difficult. A speed of 5½ knots was kept up without effort, the *Vulcan* steaming at 50 revolutions only. The *Leonidas*, under orders to convoy through the Passage, remained on the port quarter of the *Teresa*.

At 12:40 A. M., Monday, Oct. 31st, we sighted Castle Island Light and at 3:40 A. M., passed it abeam. At 10:30 A. M., Bird Rock Light House was also abeam. At 8:50 A. M., the S. W. point of Watlings Island was passed abeam, distant about three miles, and the vessels proceeded up the Crooked Island Passage inside the island. At 10:10 P. M., the light on N. E. end of Watlings Island was on the starboard beam, distant 10 miles, and at midnight it was broad off the starboard quarter bearing S. E. distant 15 miles, the ship's course was North. These data were obtained from a beam-and-quarter bearing to plot the position for a final departure. The weather was cloudy and misty all day, but the tow being under the lee of the islands and in smooth water made excellent progress, averaging a little over six knots. The *Leonidas* still continued as a convoy and kept her original position off the port quarter of the wreck.

Tuesday, Nov. 1st, began cloudy, damp, misty and threatening. At 12:50 A. M., sight of Watlings Island Light was lost, bearing about S. E. by S., distant 18 miles. At 12:55, a heavy squall from the N. E. struck the ship. The wind and sea continued to increase all through the day with every indication of a cyclone, though the barometer remained high, and even rose from 30.06 to 30.24 at 8 P. M. At 2:45 A. M. the *Teresa* signalled the *Vulcan:* "Signal *Merritt* steer to windward." This was done and all changed course from North, to N. by E. ½ E., wind and sea at N. E. Slowed down engines from 50 to 45 revolutions on account of high sea. Several times during the day the *Teresa* signalled to know the barometer.

POTOMAC RAISING THE SANDOVAL.

At daylight the *Merritt* and *Teresa* were both pitching and rolling deeply, the latter making heavy weather of it, plunging the bows under and burying the forward deck up to the turret. It was also noticeable that large quantities of water came out of the recesses around the hawsepipes in the bows, originally filled with wood but burned out by fire, and often, when rolling the *Teresa* shipped seas amidships. The *Vulcan* was riding easily but with engines racing badly. The tow lines of both were working perfectly, and no undue strain on lines or bitts was noticeable.



(By permission of Collier's Weekly.)

SPANISH GUNBOAT SANDOVAL ALONGSIDE OF VULCAN.

The gale and sea continued to increase all during the forenoon, and it was obvious that the *Teresa* was in serious trouble. A message from *Teresa* to *Leonidas* was repeated several times, "Do not go so far ahead"; but the signal apparently was not understood. An answer was also signalled to *Teresa's* question, "What is direction and distance to Watlings Island?" the answer, "S. S. E. about 30 miles. At noon *Teresa* signalled, "Ask *Merritt* if she can run to Watlings Island safely." The *Merritt's* answer was "No." The *Merritt* immediately hoisted signal to the *Teresa,* "Give your orders." To this signal the reply was made to *Vulcan* and repeated to *Merritt:* "Cast off *Merritt's* line and have her come under our lee side. Have *Leonidas* stand by on our weather side, we are going to abandon ship." In obedience to the *Teresa's* signal the towline of the *Merritt* was let go at 1:50 P. M., and as they dropped off to leeward and into the trough of the sea it was to disappear entirely with the exception of the tops of two masts, they alone being visible. Three times by wig-wag and once by navy code the *Leonidas* was signalled but failed to respond. Finally, after rounding to under the *Teresa's* port quarter, and when abeam to port, at 2:40 P. M., *Leonidas* signalled, "What is the matter with *Teresa?*" The answer was, "*Teresa* is sinking and abandoning ship, has signalled you for assistance."

Meanwhile, all hands were called to assist the distressed ship, on which were 114 brave men, 44 of them belonging to the crew of the *Vulcan.* The *Teresa* now signalled "Do not cast off our line yet,"

to which reply was sent, "Will hold on to the last and assist you by using oil." They answered "Thanks." The officers of the *Vulcan* were all ordered to direct the work of active preparation that was to be made by way of reserve, and all the men responded with energy and ability to the tasks allotted. It was learned by signals that the *Teresa's* starboard engine was making 38 revolutions per minute; and it would doubtless be kept working until the last; as it was, the commanding officer of the *Vulcan* decided first of all to hold on to the hawser, thereby giving the *Teresa* sufficient steerage way to enable her helmsman to keep the heavy sea on her starboard bow, and still be to leeward of *Vulcan*, enabling the latter to use oil to advantage when rescuing the boats began.

From the first the heavy laboring of the *Teresa* gave the impression she would founder suddenly, and that all of her people would be overboard at any moment swimming or drowning. Everything was done, therefore, during the first hour with that thought uppermost. The executive officer was directed to take charge aft with full authority to cut away the tow line immediately it became apparent

(By courtesy of Collier's Weekly.)

SPANISH GUNBOAT SANDOVAL READY FOR SEA.

that the ship was actually foundering. He was given complete charge of all details regarding the work of preparation and succeeded so well that the *Vulcan* was ready for any emergency in a remarkably short time.

A call for volunteers, to man two life boats, made by Executive Officer Lieutenant W. W. Gilmer, U. S. N., was immediately answered by an ample force, and the boats were made ready for lowering fully supplied with water, bread and meat, also with lines, life preservers and oil and a crew of six men, three of them being chief machinists, to be commanded by Lieutenant Gilmer.

All of the life preservers were gotten up, inflated and distributed, ready for use in boats and life rafts, or to throw to people in the water. Two life rafts were equipped and lowered with long lines attached, and were dropped down to the wreck. These rafts did not reach the *Teresa,* but were blown away from her. One was hauled back, but the other fouled the towing hawser, capsized and broke adrift, drifting down past the wreck, but to the eastward of it, and out of reach, as the ships were not lying directly headed to wind or to sea.

Besides all of these preparations with the same end in view, a bowline was made in every rope's end, by which a man could be hauled out of the sea. Two six-pounder rifled rapid-firing guns were converted into life guns, for throwing life lines, by reducing the charges and utilizing part of a weighted oar with a line attached as a projectile. If the *Teresa* had foundered before her people had been taken off it was the *Vulcan's* commanding officer's intention, after letting go the chain bridle, to place his vessel to leeward and then work up to windward of the men in the water and pick them up by every possible means.

Oil, one of the first requirements, was used with marvelous effect. Machinists passed it up in buckets from the hold; those on deck filled small bags with it, which were towed astern. Oil was also fed through the bathroom and other drains. Immediately the breaking top of the wave disappeared and the seas near the wreck smoothed down.

After the *Teresa* began to fill it became impossible for the *Vulcan* to keep her head up to windward, but being partially waterlogged the *Teresa* made an excellent breakwater for the boats even after she fell off into the trough of the sea. During all the preparations that were being made, there was no noise or confusion of any kind, no running aimlessly about the ship, although each man must have known that his shipmates on the *Teresa* were about to be cast into the sea, and that soon to look out for his own

safety would be the best thing that could be done. In case the ship was ordered to be abandoned each man knew his boat and station on the life raft, although some of them had gone adrift, and sharks seemed to gather as if to prevent anyone from becoming a banquet for worms.

Fortunately, none of the preparations made was needed, as the work of rescuing the crew and volunteers was nobly done by the *Merritt* with the *Teresa's* own surf boats and crew. The *Teresa* had three of these boats, two of which fortunately were on the port side. Both were lowered, as was also a catamaran. The boat on

VULCAN'S FORCE AT WORK ON MARIA TERESA.
(View of after turret and deck rigging.)

the weather side of the *Teresa* was not lowered, nor was the catamaran used. The part planned by the *Vulcan* in the rescue consisted in steaming ahead slowly and thus holding the *Teresa* up to the sea. By this means the oil, freely used, was distributed where it was most needed. At the same time the little headway given the *Teresa* enabled her officers, with helm hard-a-starboard, to keep the sea on their starboard bow, thus giving the rescuing boats a little lee, which was made safer by the efforts of the oil bags.

Their signals not to let go the line showed that the plan had their approval. At 2 P. M. the *Merritt,* splendidly handled by her captain, David Wolcott, "wore ship astern of the *Teresa,*" and came up

under her lee just in time to take off the first boat of rescued men at 2:20 P. M. There were less than four hours of daylight left in which to rescue 114 persons, including 18 Cuban coal passers, and such a sea was running as would have daunted any lifeboat crew.

To have attempted to go near enough to the great ship's side to let her people climb down or drop into the boats meant certain destruction to the rescuing party, so while the boat was towed by its painter from the ship's lee quarter, and was kept clear by two men at the oars, and by the steersman at the stern, another line was used to send the men from the ship, and in this manner: The line was made fast on the *Teresa,* and in it were two bow lines. These the men placed around themselves just under their arms, and, taking their positions, waited for the ship to roll to port, and at the word of command jumped into the sea. To the other end of the line was made fast a modern ladder as a float. The men were then hauled through the water, in most cases, to the surf boat, and then tumbled in over the bow.

It was a slow but safe process, as the result proved, for by 5 P. M. every man of the 114 was safe on board the *Merritt.* Although only 230 fathoms of hawser separated the *Teresa* from the *Vulcan,* the watchers on the latter vessel, owing to the heavy seas and driving rain and spray, were only able to see the boats of the rescuing party at long intervals when they came out of the trough of the sea.

As soon as the first boat-load was landed on the *Merritt* the surf boat was turned off to a point well off the *Teresa's* lee bow, so that the boat's crew could pull in smoother water to her side. By 3 P. M. the second boat-load had been transferred, but it was evident that more boats were needed; and at 3:19 the second surf boat was lowered from the *Teresa's* lee side. Skillfully handled by her crew she cleared the ship without injury and was dropped back to the loading point just off the lee quarter.

The first boat lowered made in all four round trips between the *Teresa* and the *Merritt.* The second made three trips, so that to rescue all hands the boats had to make the passage through those heavy combing seas fourteen times, and right gallantly those brave fellows accomplished the work. Lucky indeed was it for those rescued that the boats were manned by "past masters at the oar and helm."

For two hours men with axes, under direction of the executive officer had been stationed aft, on board the *Vulcan,* ready to cut away at a moment's notice the lines that held the hawser in case the *Teresa* should founder at any time during the transfer of her men.

Every *Vulcan* man watched with an anxious eye the great ship as she plunged "forecastle—head under" the head seas clear to the turret, and came out again, the water streaming from her hawse pipes, and showing the heel of her beam above the next big sea. Forty-four shipmates of theirs were on board the doomed vessel, and it was yet a question whether their rescue could be effected before dark. Heavy rain squalls beat the seas down a little at this time, but the wind blew harder than ever.

Struggling for a foothold on the *Teresa's* rickety bridge, her signalman, Crosset, wig-wagged to the *Vulcan* at 4 P. M.: "Don't

VOLUNTEER CREW FROM VULCAN THAT TOOK MARIA TERESA NORTH.

cast off the tow-line yet; two more boat-loads will clear the ship." To this signal the reply was sent: "All right; will hold on until the last." High up on the bridge, silhouetted against the leaden sky, and bracing himself against the fearful rolling of the *Teresa*, as she wallowed in the seas, stood Moorhoff, of the engine-room force, at the wheel. He was alone, and the last person to leave his post, for it was not until the final boat was rescuing its quota of men that he lashed the wheel, came down the bridge ladder and went aft to leave the ship with his mates.

At 4:54 P. M. the last boat-load left the *Teresa* and was safely

EVENING SCENE IN THE VULCAN'S WARD ROOM.

rescued alongside the *Merritt*. Fearing that some might have been overlooked the tow-line was still held and the wreck searched with glasses through the rain and spray for some sign of life. By this time the wreck was low in the water and water-logged, shipping quantities of water with every sea and settling rapidly.

After making sure that the boats had finished their work of rescue and that all had been taken off, the *Vulcan's* engines were stopped, the hawser slackened, and finally, at 5:11 P. M., the order was given to cut away the tow line. Two blows of an axe severed the lines that held the chain bridle to the bitts on our starboard and port quarters, and as the links rattled out through the stern chocks three cheers were given as a salute to the Stars and Stripes flying in defiance of the elements at the *Teresa's* jack yard, and also to the bravery of the *Merritt's* men who had made such a gallant rescue of their shipmates. Twenty minutes later it was so dark that the *Teresa* was only a black spot against the horizon, and at 6 P. M. nothing but the lights of the *Merritt* and *Leonidas* could be seen, while the gale howled and the sea rose higher than ever.

The *Vulcan* was then hove to, heading N. E. by E., with engines turning as slowly as possible. The *Leonidas* and *Merritt* did the same, but headed N. E., and the vessels remained in sight of each other near the wreck. At 7 P. M. the *Merritt* put her helm aport, steamed off and disappeared. The *Leonidas* was lost sight of on the port quarter about 9:30 P. M. Neither vessel made any signals and both seemed to be safe and in good condition. The gale lasted all night, moderating slightly about daybreak.

As soon as daylight came Wednesday, November 2, the *Vulcan* "wore ship" and steamed down a general S. W. course, zig-zagging across to pick up her consorts. The *Leonidas* was sighted at 6:50 A. M. heading N. E. She soon turned around, however, and joined

(Original negative by Mr. J. A. Scott.)

LAST VIEW OF THE MARIA TERESA.

Snap-shot taken from the stern of the Vulcan after the crew of the Teresa had left her. The Merritt is seen to the right.

in the search for the *Merritt,* following for about 12 miles. In this way it is believed that all the probable and possible ground over which the *Merritt* could have passed while "hove to" was thoroughly searched. It was hardly expected that she would be found, as it was believed that she had started for New Providence Channel or Nassau soon after dark to seek shelter and get rid of her large number of passengers. They reached Charleston, S. C., many of the men without sufficient clothing, some of them in their underclothing, and without shoes, stockings or hats. It was afterwards learned that the *Vulcan* had encircled the *Teresa,* and although lookouts were in the cross trees, on the bridge and forward deck, the rain and mist prevented the wreck from being sighted.

Criticism is easy and natural for those without responsibility; they do not even require facts on which to found an opinion. It has been asked if it would have not been well to have left a lighted signal on the *Teresa* so as to keep track of her during the the night. It would, but they did not have any lanterns, and the recent experience of the Hamburg-American Line steamer *Bulgaria,* from New York on January 28, for Hamburg, through continuous gales from February 5th to the 19th, sighted by three vessels, and twice towed by one of them, yet lost in the night to all of them, finally reaching the Azores, 800 miles distant, illustrates the uncertainty, after standing by a disabled vessel, of ever seeing it again.

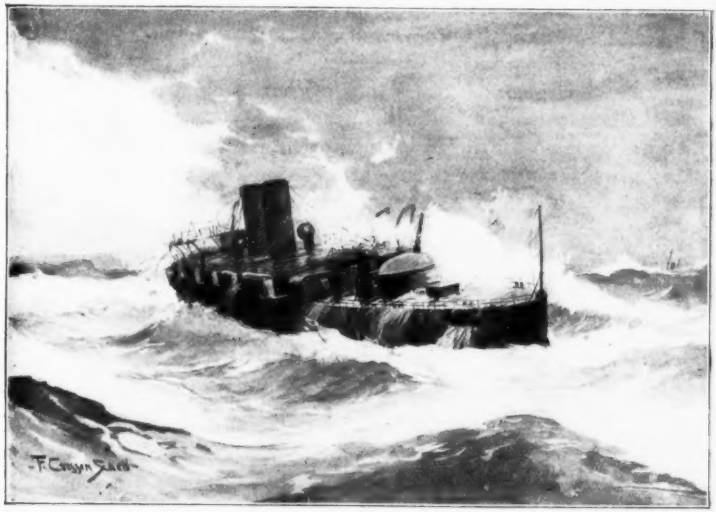
At 8:15 A. M., November 2, the *Vulcan* steamed for the *Leonidas,* and signalled for permission to proceed. It was granted, adding: "We will stand by until 4 P. M., unless we sight them sooner." During the day the gale increased, and towards night gave every indication of developing into a cyclone. At 5:40 we were again "hove to" to watch shifts of wind. At 7:40 it was thought best to steam to the eastward to allow the storm to pass. The course was accordingly changed to E. N. E., but by midnight it was found the weather was not improving, so the course was again changed to North.

Fortress Monroe was reached shortly before midnight November 5, where the safety of the rescued men was learned. Next morning the *Vulcan* was ordered to the Norfolk Navy Yard, and on reaching there was informed that a steamer with two smokestacks was reported ashore on Cat Island, near Bird Point, and to fit out immediately and return. General quarters were sounded and orders were read. Expressions of sadness, disappointment and despair filled the faces of the crew, and when "piped down" many of them seemed so dazed they did not leave their places until again ordered. In fact,

they were about worked to a stand still. Immediately eight of the best men were sent to the Naval Hospital, some with typhoid fever, and many others were sent home as convalescents.

Volunteers from the other ships were called for, and responded so that in about an hour there were 299 men at quarters. Coaling ship proceeded day and night, and on the following morning, November 7, at 9:45 the *Vulcan* was again under way, passing out between Capes Henry and Charles about 12 o'clock, finding in about an hour that same old storm that had already given so much trouble, returning up the coast. The *Vulcan* fought it all the way down, and in three days found the *Teresa,* located as had been described, within a few miles of the spot where Columbus is supposed to have first landed.

With some difficulty a boat was launched, and on rounding the *Teresa's* stern it was found she was resting on coral rock in 20 feet of water at low tide aft, although she drew 30 feet when abandoned. With each sea the sides of the ship creaked and groaned, as they were working badly, so much so that it was deemed unsafe to leave a marine guard on board, although possession had been taken in the name of the United States Government. The Stars and Stripes were made fast to the smokestack, as the military mast had been pounded out, and had gone by the board, lying under the ship. The engines did not



(By courtesy of Leslie's Weekly.)

MARIA TERESA ASHORE ON CAT ISLAND.

move with the ship in its vibrations, as they had gone through its bottom. A 3½-inch cross-tie rod between cylinders had broken, the space between ends being 7½ inches, showing that everything had gone adrift and it was impossible to save the wreck. The *Potomac* was dispatched to Nassau to cable the news and ask for instructions, which were given.

An accident to the *Potomac's* machinery compelled the *Vulcan* to take off two heats in the brass foundry, as castings were required for repairs. It required two days; cargo ports could not be opened, and the ship was rolling badly. Imagine, if possible, an attempt to "pour off" at sea, with two men steadying the one holding the crucible, while others stood ready with shovels and sand to cover the fluid metal should it spill or break away, and a fire brigade ready with hose and buckets if required.

The Secretary of the Navy, in his annual report, including the operations of the war with Spain, states: "The desirability of having a vessel accompanying the fleet thoroughly equipped for making repairs was early apparent. . . . Her usefulness has been universally admitted."

The Engineer-in-Chief of the Navy, Rear Admiral George W. Melville, U. S. N., in his annual report, also including the operations of the war, states: "The *Vulcan* proved of the highest usefulness to the fleet, making repairs of all kinds and furnishing much needed supplies to every department of nearly every vessel. Her unusual facilities and the large number of skilled mechanics on board (about 100) enabled her to make repairs of all kinds, including hull work, gun mounts, dynamos, main steam pipes, main piston rods (for small ships), brass castings without end and iron castings in considerable quantities. This last is especially interesting, as the first instance of the successful use of the cupola on ship board."

Captain F. E. Chadwick, U. S. N., in command of Admiral Sampson's flagship, the *New York*, speaks of the *Vulcan's* work: "Thoroughly efficient and well-looked-after machinery mean facilities for instant repairs. This last element appeared upon the scene somewhat late, but none the less welcome. The *Vulcan* arrived in Guantanamo Bay well equipped both with mechanics and tools, and did most valuable service. . . . She was not large enough. It would have been better to have had a considerably larger ship."

Admiral Cervera, in command of the Spanish fleet, also appreciated the features brought out in the above reports, as is evident from his own communications to the Spanish Government before he was

ordered to leave the Cape Verde Islands for Cuban waters, in that he forcibly brings to the attention of that government his inability to make any repairs to the vessels of his fleet, even should he strike a telling blow upon some American commercial centre.

The writers desire to thank the officers and crew of the *U. S. S. Vulcan* for valuable assistance which they have rendered, and to acknowledge their indebtedness for photographic views, engineering data and other information.

Especial acknowledgment is made to the Engineer-in-Chief of the Navy, Rear-Admiral George W. Melville, U. S. N., for most helpful encouragement and valuable statistics, drawings and information.

MACHINE-SHOP MANAGEMENT IN EUROPE AND AMERICA.

By H. F. L. Orcutt.

VII.—ELEMENTS OF A MODERN MACHINE SHOP.

MOST machine shops are not made, they grow, and consequently there are few, if any, in which every detail is arranged in accordance with the latest practice,—even in those cases where the proprietors themselves are thoroughly familiar with the latest developments in the art of producing modern machine tools. I know of no machine shop in which the latest equipments are combined with buildings of the best design. Having had the opportunity of being intimately connected with the designing and equipping of large machine tool works, in which it has been the intention to adopt every modern improvement, I have had special occasion to consider this problem, and have followed the development and realization of plans which, for three years have called for unremitting application on the part of those interested, and are not yet consummated. The manufacturer of machine tools is confronted with nearly the same problem which any other manufacturer has to solve when erecting new works. Unlike most articles of manufacture, however, machinery is never produced in what can be called, comparatively speaking, large quantities. It follows then that the organization necessary to meet the requirements for producing in small quantities must be different from that which is possible where operations can be repeated day after day, the year round, on parts remaining unchanged in design while thousands, or perhaps hundreds of thousands, of one particular article are produced. In considering the organization necessary for the production of machine tools, heavy machinery will be left entirely out of the question, and only such machinery will be considered as is made in fairly large quantities, of medium weight, and of standard design. By small machines are meant those which weigh from 500 to 2,000 lbs., in some instances perhaps 3,000 lbs. The first natural division which should occur in organizing a machine shop for the manufacture of machinery of this weight, is, between those departments in which small parts are produced, and those for the heavier work, such as beds, columns, floor plates, etc. For heavier work, most of the operations will, of course, be confined to milling, planing and boring. For the

lighter work all the operations common to machine parts must be performed, such as chucking, turning, grinding, milling, planing, scraping, drilling, tapping and, finally, assembling. As any great amount of repetition work is impossible, it is out of the question for any machine manufacturer to put down a complete plant of machines arranged in departments, each department being confined to the production of a single part. In order, however, that organization may be established, and that a high degree of productivity may be possible, work must be grouped under various operations; thus, different parts which must pass through the same departments, must be operated upon by the same machines,—with a change of fixtures. The essential elements of a modernly organized machine shop may be enumerated in the following manner:

1. Casting Store Room.
2. Planing and Milling Department for light work.
3. " " " " " heavy "
4. Scraping Department.
5. Chucking Department.
6. Turning Department.
7. Screw Machine Department.
8. Gear and Rack Cutting Department.
9. Grinding Department.
10. Polishing Department.
11. Drilling Department.
12. Assembling Department for Machines.
13. " " " " Small Parts.
14. Inspecting Department.
15. Store Room for Finished Parts.
16. Store Room for parts in process of manufacture.
17. Drawing Room.
18. Drawing Store Room.
19. Pattern Shop.
20. Pattern Storehouse.
21. Smith Shop.
22. Hardening, Tempering and Annealing Department.
23. Steel Stores.
24. Cutting off and Centering Department.
25. Foundry.
26. Laboratory.

To the above there are many sub-divisions and minor departments, but to deal with them would extend the limits of the present paper too far, therefore only the briefest comment on each heading will be possible. Again, the actual divisions and groupings of departments and the number of foremen to be employed necessarily depend on the size

of the shop. The elements enumerated, however, exist in all machine shops. Comments which follow refer especially to *large* shops, where a limited variety of machinery is made in large quantities; several of these exist in the United States, though the Loewe shops in Berlin are the latest of this type.

Casting Store Room. It is practically impossible always to fix the exact date when castings will be wanted in the shop; even if it were, the foundry cannot always be relied upon to deliver. To avoid delays consequent on non-delivery of castings, and to have material ready at the moment it is wanted, it seems necessary to provide in every machine shop an ample store room for castings of standard parts. Without this department, economic disposition of work and exact control of costs of material is difficult. In all machine shops valuable floor space which ought to be used for manufacturing purposes is occupied simply as storage room. Of course, space can be most economically used in a specially fitted store room, which should be so arranged that stock can be quickly inventoried, and the heavier parts easily transported.

Planing and Milling of light parts may be arranged in one department under one foreman, as surfaces are most easily reduced, in many cases, by a combination of the two operations. Some operations are performed more cheaply on the milling machine, others on the planing machine,—the parts going from one to the other. Of course, in this case it is the foreman's duty to reduce costs by carefully studying the operations and applying them to the machines best adapted for producing the cheapest work. Many parts are handled more cheaply without the use of special fixtures or appliances, while, in other cases, where parts can be more largely duplicated and are of special form, they can be produced more cheaply with the aid of fixtures and jigs, which are made for different parts and are used on the same machine.

In planing and milling heavy work, fixtures are rarely necessary, and the same advantageous methods can be employed by combining the milling and planing machine work in one department. Some parts can be wholly planed, some parts wholly milled, and others partly planed and partly milled. It is well to have this heavy work also under one foreman, whose whole duty is to produce flat finished surfaces cheaply by whatever methods or appliances are best adapted to the end in view.

Scraping Department. This important branch can be made the object of more careful development than is usually practiced in machine-shop work. The production of true scraped surfaces is an art; the

tools to be used are of special form and should be in the hands of skilled workmen, and the appliances for handling and holding parts while being operated upon, are numerous. This department is worthy of more study and special attention from the machine tool manufacturer than it usually receives.

Chucking. Truly flat surfaces and truly cylindrical holes are, of course, the foundation of all good machine work. It is surprising that this chucking, or boring, has received so little attention from European machine-tool makers. Holes of varying dimensions, and out of true, are a fruitful source of bad workmanship and expensive fitting. The practice of maintaining the chucking department is now thoroughly established in American machine shops, even in those with the smallest pretensions. Everything requiring cylindrical holes should be sent to this department, where parts are bored and finished on chucking machines specially adapted to the purpose, and holes are kept to size by limit gauges. In this way accurate work can be done at from one-half to one-third the expense of ordinary methods, as practiced in European shops, by the lathe hands, or turners.

Turning Department. The equipment for this department is comparatively simple, although much greater saving can be effected by more study of detail than is commonly carried out. Automatic lathes can be largely employed, and, when properly arranged with fast feeds and, in some cases, with two or three cutting tools, will effect great saving. Expensive smith work can often be avoided by a comparatively small investment in automatic lathes which take heavy cuts at fast feeds,—one operator being able to attend to two or three lathes. Where a grinding establishment is used in connection with the production of cylindrical parts, fast feeds and rough cuts can be made, thus doing away with a large amount of the so-called skillful turning which is practiced in many cases, by machine-tool makers, and is a waste of effort and files, and which, moreover, produces poor work.

Screw Machine Department, fitted with machines for the production of screws, nuts and bolts. Automatic turret machines have been rapidly adopted within the last few years by leading makers. The scope of the screw machine is fast extending to such an extent that in large works a greater part of the automatic and hand machines is used for producing a great variety of machine parts, besides the ordinary machine-screws, such as pins, studs, washers, oil caps, etc. The most important developments have lately been made in the heavier types of turret machines, which should come in this department, so that they are replacing lathe work, and are turning out parts up to 2 inches dia-

meter and 24 inches long at 50 to 100 per cent. cheaper than the lathe. All this class of work should be specialized in one department under a competent foreman, whose sole occupation should be to perfect and extend the use of the turret machine, which has a great future before it.

Gear and Rack-cutting Department. As cast gears and racks are fast becoming obsolete in the best machine tool practice, this department should receive more and more attention at the hands of machine-tool makers. In the best works it is considered worthy of the supervision of the highest class of foremen and of engineering talent, as gearing is a science in itself and the production of perfect running gears enters largely into the successful working of nearly every machine tool. Accurate and perfect running gears can now be produced by the aid of automatic gear-cutting machines, at a price that is claimed by some makers to compete with that of the ordinary cast gear. The recently developed Warren bevel gear machine makes it now possible to produce accurately cut bevel gears at a very low cost.

Grinding. This important branch has really, within the last few years, had more to do with changing machine-shop methods than almost any other factor. The highly developed and accurate-working cylindrical grinding machine is within reach of every machine tool maker, and the production of accurately finished parts on such machinery has been largely instrumental in reducing the prices and increasing the accuracy of modern machine tools. It is now recognized that no method of finishing cylindrical and, in many cases, flat surfaces is employed which approaches so near perfection as that of grinding. One operator can attend several machines, and produce work which, for accuracy and cheapness, cannot be turned out by the most skilful turner or planer hand. Surface grinding should receive serious consideration from manufacturers, even as a means of merely finishing flat surfaces, without any consideration of accuracy.

Polishing. The special object of a polishing department is to remove from the lathe hand an operation which can be performed by unskilled labor, and on most ordinary machines. At the same time, the removal of emery work from the lathe which is used for accurate turning, is but reasonable and profitable. This polishing department should be separated, in the same way as the grinding department, from the other machine work.

Drilling Department. This department cannot, perhaps, be too sharply separated from the others; nevertheless, it calls for distinctive consideration, and an examination of the latest methods of jig-

ging and boring, even of large parts such as lathe head-stocks and carriages, will show that, as a special department, it is worth more consideration than most machine-tool makers give it. If the shop is properly organized, this work can be profitably separated and put under special supervision, the proper machines made use of for different operations, clumsy methods of boring abolished, work done cheaper, and standard dimensions more easily maintained.

Assembling Department for Machines. The principal requirements are good light, special facilities in the way of cranes and hoists for handling parts, and comparatively little machinery,—the principal item for consideration being cheap transportation. Facilities for readily inspecting, testing, and running machines should also be provided.

Assembling Department for Small Parts. The chief requirements are good light and work benches with a small number of machine tools, principally drilling and tapping, as of course it should be the object throughout the various departments to send parts to the assembler or fitter which require little or no machining.

Inspection. A department which nominally exists in nearly every machine shop, but is, in reality, properly developed in few in either Europe or America. The inspection of a machine tool should begin with its finished parts and should end only when it is ready to ship. Spindles, bearings, planed surfaces and scraped surfaces should be inspected as fast as they are finished; without this the final inspection, when all parts are assembled, is of little value. Unless this detailed inspection is given, no machine can be guaranteed to stand the test of actual service, even if, as an assembled machine, it shows no imperfections. To prescribe the tolerances and limits between that which is ideal and that which experience shows to be practical and commercial, is not easy; it is, however, necessary to work out thoroughly a system of inspection for those who wish to maintain a high standard of excellence.

Store Rooms for Finished Parts. The object of this department is to maintain in order and keep on hand a supply of such finished parts as can be produced in large quantities. They may be single pieces or perhaps sections of machines which are ready to be combined with the heavier parts in the heavy assembling department. Proper organization would, of course, naturally dictate that a system of inspection should be maintained in this department, and that the stores should be under careful management.

Store Room for Parts in Process of Manufacture. This is for

the proper storing and control of such parts as, during the process of manufacture, cannot be finished at once, but have to await their turn before they can be brought to a finished state in the various departments; these must be cared for, must be under control and easily inspected. This room can practically be combined with the Store Room for finished parts.

Drawing Room. Although this is aside from the general manufacturing equipment, the drawing room system is largely responsible for the success which may be attained in the machine shop. A good or bad system of drawing may mean either expensive or cheap work. Proper drawings, which will assist the workmen, must be produced, and the appliances and organization for turning them out must, of course, receive careful attention. It is really the heart of the machine shop, and its influence extends to every department and affects every workman. Anything like a detailed discussion of the best methods cannot be attempted in the present article, and the department can, at the most, be simply enumerated as one of the important factors.

Drawing Store Room. This is a department which seems to be very seldom seriously considered, either in planning new works or in the maintainance of old establishments; it should, however, receive careful attention. It should be central with the entire works, in such order that careful records can be kept of every working drawing,—no matter of what date, and so kept that they can be easily consulted. As these records are valuable, fire proof storehouses are indispensable requisites of a drawing store room.

Pattern Shop. While the equipment of a pattern shop is not at all extensive, the cost of production can be reduced, and accurate and cheap work turned out, with the aid of labour-saving machines and the excellent carpenters' tools that are now obtainable. The best of facilities should be planned in the way of a well lighted and roomy shop, with good fittings.

Pattern Storehouse. The chief requirements of a pattern storehouse are that it should be absolutely fire proof and arranged so that every pattern is available, with the least possible annoyance and delay, and stored in as small a space as is consistent with good order. Systems of recording and numbering patterns are numerous. At the hands of some manufacturers, the pattern storehouse has received great consideration; it should be light and dry, and an even temperature should be mantained.

Smith Shop. The production of a machine-forging is an ex-

pensive operation, as it usually means the work of two or more men and a fire. Consequently, the machine shop should avoid forgings as much as possible, and, in the latest practice, the endeavour is made to do this by using, as far as can be, parts cut from the bar. On account of the expense of machine forging, the equipment of the smith shop becomes, of course, an important item. Smith fires should receive attention in the way of special design, the latest appliances for taking away smoke, and for furnishing blast. Where parts can be made in quantities and it is necessary to forge, the trip-hammer and drop-hammer or steam-hammer can be used.

Hardening, Tempering and Annealing Department. Appliances for this department are various, and almost every manufacturer has developed his own special methods of case-hardening, tempering and annealing. The requirements of a modern establishment should embrace the best and most economical furnaces, labour-saving appliances for handling material, and special facilities for tempering small tools. By the careful manipulation and control of this department immense savings can be effected in any machine shop.

Steel Stores. This should embrace specially designed fixtures for holding material and the appliances best adapted for handling parts with as little hand labour as possible. Many manufacturers favour the system of standing the bars of material on end where vertical space is available.

Cutting-Off and Centering Department. This should be in close proximity to, or perhaps form a part of, the steel storehouse. Such appliances should exist as would allow the cheapest transportation from the racks, which hold the material, to the cutting-off machines. Centering machines are naturally worked in connection with the cutting-off, so that parts ordered from the machine shop are supplied cut accurately to length and centered, in most cases, ready for turning.

In connection with the last-mentioned items three—viz. smith shop, hardening, tempering and annealing department, and the steel stores—it seems but natural that they and the cutting-off and centering department should group together in a well organized factory, as the steel storehouse must furnish material not only to the cutting-off machines but also to the smith shop, and many of the parts which are cut off or forged have to be annealed before they are taken to the machine-shop.

THE ENGINEERING DEVELOPMENT OF PORTO RICO.

By Herbert M. Wilson.

DISCOVERED 400 years ago by Columbus, Porto Rico, after three centuries of the mediæval misrule of Spain, has not yet awakened from its slumbering soil the full measure of the harvest which awaits the garnering of modern industry. Had a fraction of the money and energy devoted to extracting from its people the last centavo of tribute been expended in developing its agricultural possibilities, Porto Rico would be to-day the garden spot of the West Indies.

One has but to turn to its sister island, Jamaica, which has flourished for a less period under Great Britain's beneficent rule to realize what the future holds in store for her. While Jamaica is traversed in all directions by magnificent highways over which produce is cheaply transported to market, Porto Rico boasts but one military road. While Jamaican coffee, oranges, and bananas are world-famed for their quality and are prodigal in yield, Porto Rico produces the same in insignificant amount and of unheralded, though excellent flavor. Yet no one who has seen the two islands and who realizes the richness of the soil, the mildness of the temperature and the humidity of the climate of Porto Rico, can doubt for an instant which would be the more productive under an equally liberal and intelligent government.

The sanitation of the cities of Porto Rico and their water supply must be improved to make them habitable by Caucasians. Modern systems of inland transportation by railways or highways must be provided, that every portion of the island may be easily accessible to the investor and home-seeker, and that the teeming products of its soil may be cheaply conveyed to the seaboard.

The climate of Porto Rico is naturally salubrious, and owing to its steeply rolling and well drained surface nothing but man's own indolence and filthiness prevents its being one of the healthiest of tropic countries. So bountifully has nature lavished her best gifts on this, the latest addition to territory under Anglo Saxon rule, and so little have its Spanish rulers done to develop and utilize these, that of her it may be truly said, "every prospect pleases and only man is vile!"

It is my purpose in this paper to show the resources of the island in water supply, something of its climate and topography, and to point out how these may be utilized to its improved sanitation and its transportation facilities.

Situated between latitudes 17° 54′ and 18° 30′ N., and longitudes 65° 13′ and 67° 15′ W., the island of Porto Rico is well within the torrid zone. It is in the same latitude as the city of Mexico, the Hawaiian Islands, the centre of the Sahara Desert and of Bombay, India. Because, however, of its situation as the easternmost of the Greater Antilles, its climate is so tempered by the trade winds as to render it

TRADE-WIND BLOWN TREES, SAN JUAN.

more moist and more salubrious than that of any of the places named, with the possible exception only of the Hawaiian Islands.

The trade winds here blow with unceasing regularity throughout the year, yet not with such force as to be disagreeable. The precipitation on the island is as varied in amount and character as that of the entire United States, a fact due to these trade winds and to the topography of the island. Heavily moisture-laden from the warm ocean, the winds impinge against the mountains where the contained moisture is quickly condensed and squeezed out of them as from a sponge, falling in heavy showers of sudden occurrence but short duration. Passing southward and westward the same winds continue to precipi-

MORNING MIST OVER TOBACCO FIELD, CAGUAS.

tate even more abundantly at the summits of the mountains near the centre of the island, and passing these they suddenly are freed and expanded, and being thus given the power to carry a larger amount of moisture, little rain falls from them over the southern and western slopes.

These conditions are clearly recorded in such meteorologic data as have been collected by the United States Weather Bureau from the archives left by the Spanish government. At Hacienda Perla, the average annual precipitation is 123 inches, yet at San Juan, but 15 miles farther west, the average annual precipitation is only 54 inches.

Apparently great as are these extremes of precipitation, they are as nothing compared to those between points on the south coast and those on the north. According to such data gleaned from Spanish records, as are now available, it appears that the average annual precipitation on the southern slopes of Porto Rico is but 20 inches, as against 50 to 123 inches on the northern slopes. Moreover, this is distributed quite irregularly, there being an authentic record of nearly three years without an inch of rainfall at Cabo Rojo near the extreme southwestern end of the island; while at Guayama, immediately south of San Juan, there is one record in 1893 of 13 months without a drop of rain.

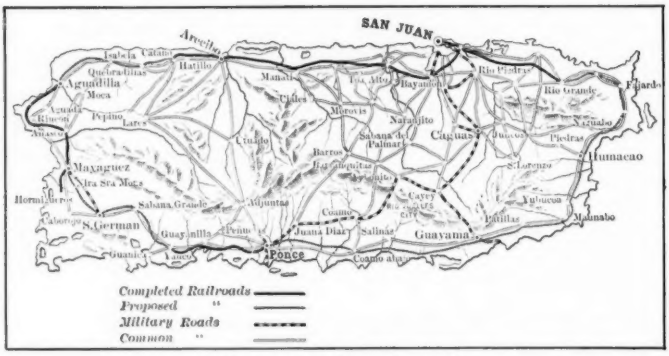
The above facts are important in connection with any discussion of the water resources of Porto Rico, or of highway transportation or of city sanitation, and they show clearly that any generalizations on these subjects are necessarily valueless, and that small as is the island, each particular locality of very limited extent must be considered as a problem by itself, in connection with any public work or private engineering undertakings.

The topography of the island of Porto Rico exerts fully as much influence on problems for the future development of the island as does its precipitation. It is exceedingly mountainous and highly eroded, though none of its summits attain great altitudes. It is noted for the abruptness with which the foothills of the mountain slopes plunge into the ocean and the absence of any true coastal or marginal plain. A

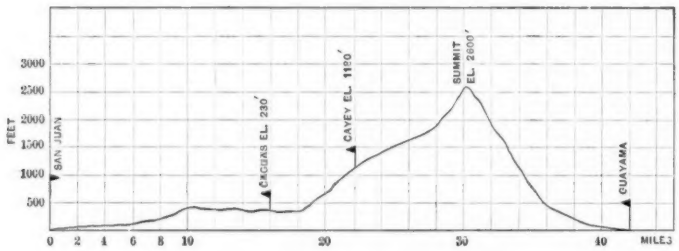
TOPOGRAPHICAL MODEL OF PORTO RICO.

series of connected mountain ranges extends irregularly through the length of the island from its northeastern point to the eastward of San Juan, to its extreme western point near Cabo Rojo. These form a main divide between the drainage of the northern and southern coasts. The most commanding of these mountain ranges is the Sierra de Luquillo, lying between San Juan and Fajardo, the highest summit upon which, El Yunque, has an elevation of approximately 3,750 feet and is the highest point upon the island.

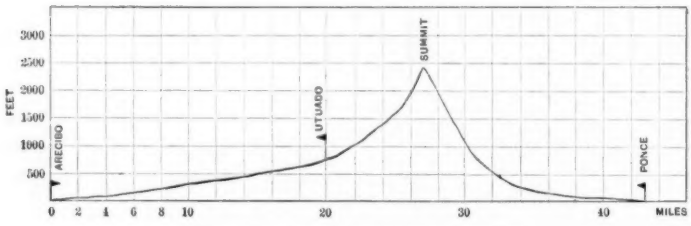
To the south the main spur of the Luquillo connects this mountain range with that of Sierra de Cayey, the highest summits of which attain but a little over 3,000 feet in altitude. These mountain ranges skirt closely the eastern and southern coasts, so that the greater portion of the drainage of the eastern third of the island is to the north, the eastern and southern coasts receiving the drainage from a narrow



MAP OF THE ISLAND OF PORTO RICO.



CROSS SECTION PROFILE, SAN JUAN TO GUYAMA.



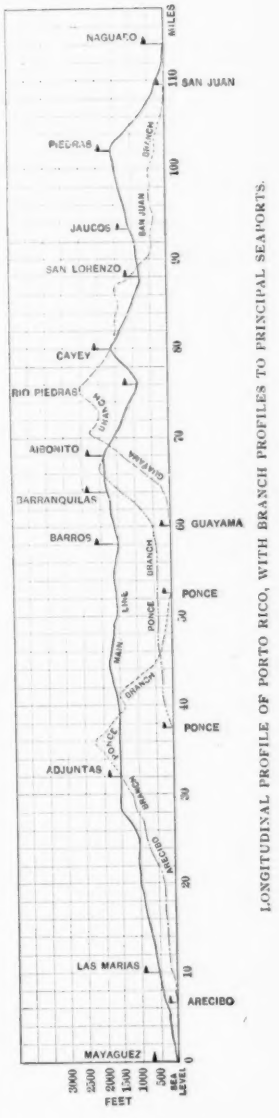
CROSS SECTION PROFILE, ARECIBO TO PONCE.

belt of country but 5 to 10 miles in width. West of Aibonito the Sierra de Cayey merges into the Cordillera Central, a great mountain mass, which extends thence with altitudes of 3,000 to 3,200 feet to its culminating point, El Guilarte, the second highest peak on the island, 3,610 feet above the sea. West of this point several well defined mountain spurs reach the sea coast to the north and south of Mayaguez.

This controlling east and west system of mountains is the barrier against which the trade winds beat, and its crests mark clearly the dividing line between the humid regions of the northern and the semi-humid regions of the southern coasts. It is also the main divide which separates the waters flowing toward the northern ocean from those flowing to the southern sea, and as its average position is about one-third nearer to the southern than the northern coast the drainage area to the north is about twice as great as that to the south.

It is evident that the mountain slopes are steep, the fall of the rivers great and the velocity of the water high. It is also evident that those streams which flow to the north are three times as long as those flowing to the south, the former having an average course of 25 to 35 miles, that of the latter averaging but 5 to 10 miles. Those to the north, therefore, draining the greater areas, are necessarily greatest in size and volume, and are less abrupt in slope than those draining to the south, which plunge from 3,000 feet to sea level within comparatively few miles.

Porto Rico is unusually well watered because of the comparative humidity of the climate. Flowing into the northern ocean are twelve streams of considerable size; toward the west coast are four of relatively equal size; toward the south are seventeen of lesser magnitude; while to the east are six of still less magnitude. Each of the larger rivers has its sources high among the summits of the Central Cordillera. Those flowing to the north and west are characterized alike by



LONGITUDINAL PROFILE OF PORTO RICO, WITH BRANCH PROFILES TO PRINCIPAL SEAPORTS.

FORDING RIO LOIZA NEAR CAROLINAS.

FORDING RIO CANOVANOS, LUQUILLO MOUNTAINS.

precipitous descents of from 1,000 to 2,000 feet in the first five miles of their course; thereafter they flow more leisurely and with necessarily increased dimensions to within about five miles of the coast, where they emerge at sea level in the alluvial playas or river bottoms about their mouths. On the southern and eastern slopes the rivers fall away more abruptly as mountain torrents, from the highest summits to within 100 feet of sea level in the first five miles.

On the northern coast several of the larger rivers have, at low water stage, bed-widths of from 150 to 200 feet, average depths of 2 to 3 feet and minimum discharges of 150 to 1,000 second-feet. On the southern coast the width of the stream beds is in a number of cases

DRY BED OF RIO PORTUGUES, NEAR PONCE.

as great as those on the northern coast, but owing to the irregularity and small amount of precipitation the average amount of discharge is but 50 to 75 second-feet. Again, the northern rivers, more like those of other humid regions are less subject to sudden flood rises of great amount. The southern streams, like those of our western plains, are subject to sudden freshets of great volume, subsiding rapidly to their customary small discharge.

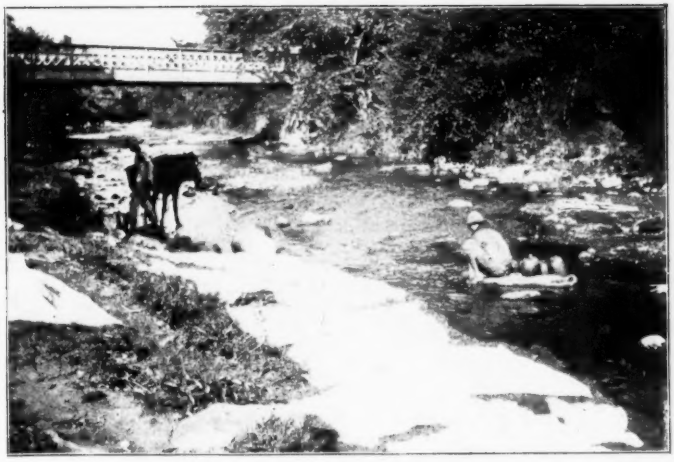
The largest river on the island, the Rio Loiza, which enters the north coast about 15 miles east of San Juan, has at Carolinas, the point at which it leaves the mountains, a surface width of about 220 feet, with an average depth of 3 feet, and a velocity of approximately

DRY RIVER BED AND IRRIGATING CONDUIT.

2½ feet per second, making its minimum discharge about 1,600 second-feet. In flood the same river discharges probably as much as 15,000 to 20,000 second-feet. Twenty-five miles from the coast at Caguas, and above its main branches, Rios Gurabo and Loiza, one of its branches, Rio Turabo, has a surface width of 100 feet and an average depth of 1½ feet, and a velocity of about 3 feet per second, making its discharge nearly 450 second-feet.

As an example of the dimensions of the south coast streams, the Rio Coamo at the city of the same name and at a distance of about ten miles from the coast and an altitude of 350 feet, has a surface width of about 100 feet, the river bed being about 250 feet in width. Its average depth is nearly 2 feet and its minimum discharge about 100 second-feet, its maximum flood discharge perhaps reaching as great a volume as 5,000 to 8,000 second-feet.

The island of Porto Rico is a virgin field for the exploitation of the promotor through the resourceful skill of the engineer. As yet, practically no engineering work worthy of that name has been done, other than the little governmental improvement of the harbor of San Juan and of the one military road which crosses the island. The opportunities for development of water power which may be utilized by electric transmission, either in running sugar mills or other machinery, or electric railways, or in electric lighting, are abundant and well distributed. Where rivers of considerable volume fall 500 to 1,500 feet



BRIDGE OVER SEMI-DRY RIO COAMO.

BRIDGE NEAR CAGUAS.

REPAIRING MILITARY ROAD NEAR CAGUAS

A GOOD (?) MOUNTAIN ROAD.

in a few miles, the power which is available is evident. Moreover, there is such a vast field for public improvement in transportation facilities and in the use of machinery that one has no difficulty in drawing in the imagination a vivid picture of what this water power must mean for the future of Porto Rico.

Aside from such public works as were a necessity of the military control of the island or such as aided directly to the comfort of the Spanish officials, the degree of progress heretofore made in the introduction of civilizing attributes is only such as was attained in the United States two centuries ago. The people live chiefly by agricul-

BETWEEN CAYEY AND AIBONITO.

IN THE LUQUILLO MOUNTAINS.

tural pursuits. These are carried on by methods and tools such as were used by the early colonists of America. The means of insular communication by roads and trails are no better than those found in the back woods. The legal conduct of the provincial governments and cities, and the water supply and sanitation of the latter are equally primitive. This in spite of the fact that the island has been completely deforested, that almost every square foot of the land is or has been under cultivation, and that every portion of the country is well inhabited.

The population of Porto Rico consists of 1,000,000 people, of whom only 325,000 are negroes. The largest city on the island, San Juan,

ROAD DESCENDING AIBONITO GRADE.

has but 30,000 inhabitants; the second, Ponce, 22,000; the third, Mayaguez, 12,000, after which there are a dozen smaller villages, having 10,000 inhabitants and less, scattered generally throughout the interior. The density of the population averages 225 per square mile. These figures and the smallness of the cities indicate how generally the inhabitants are distributed throughout the island. That there is certain to be in the immediate future an astonishing rejuvenation of this land accompanied by the construction of many important engineering undertakings is evident from the bare recital of the above. How extensive are the resources and what is the full measure of its possible future development might be further emphasized by a statement of its present relatively insignificant trade.

Nothing of importance can be expected from the development of the mineral resources. These are insignificant in amount and variety, as shown in an extract from the Twentieth Annual Report of the United States Geological Survey, by Mr. Robert T. Hill, my companion in studying the island. The most generally distributed structural material is clay. From this, bricks, tiling, and to a lesser extent pottery, are already made. But a small proportion of these, however, which is required for local uses is manufactured in the island,

the larger amount, especially of tiling and pottery, being imported. Materials for building masonry structures are abundant and well distributed. Good clean, sharp sand is found in nearly all the rivers. Chalk, clay, and silica for the making of artificial cements abound in the costal formations. Both white limestone in the costal formation, and blue and gray crystalline limestones in the mountain regions, abound, and these are well adapted to the making of lime. Many of the impure limestones appear to be well adapted to the making of natural cement, but, as fuel is scarce and expensive, it is doubtful if these can be profitably utilized. Building stone of all kinds is abundant, including the hard blue and gray massive limestones found everywhere in the mountains, also volcanic bowlders, and lumps of porous white limestone, which are popularly used by the native masons. Near Juana Diaz is a belt of beautiful marble of great hardness and variegated color, which is extensively used for bridge piers and other structural purposes. A fine flagstone used in San Juan for sidewalks is abundant and is quarried chiefly between Cayey and Aibonito.

Excellent material for road metalling is furnished by all of the above, and also is found everywhere in the volcanic tuffs, of which the larger portion of the central mountain mass is composed. Moreover, good riprap material for dams and small stone for road metal is found conveniently for local use, in many places, especially on the north side of the island. This occurs as a hard white coral limestone which is

MUDDY ROAD NEAR AIBONITO.

IRRIGATION DITCH NEAR PONCE.

IRRIGATED SUGAR CANE NEAR PONCE.

crystalline and breaks into firm, sharp angular pieces. Gypsum is found abundantly along the southern slopes of the mountains, especially to the north of Juana Diaz and near Ponce. This material is extensively used for plaster, both for house interiors and their stuccoed exteriors.

The industrial development of the island, will, as shown, be on the lines of increased agricultural output. Already much has been done in the way of encouraging the coffee product, as this was one of the articles chiefly desired for export to Spain. The production of sugar also has been well encouraged in the past, and the development in its production must in the future be largely in the direction of improved mechanical separation and crystallization rather than in its cultivation. Great agricultural development may, however, be expected in the production of a better grade of bananas, and these in greatly increased quantities; also in the cultivation of oranges, lemons and similar fruits. All grow abundantly, but practically in a wild state at present. No attempt has been made to introduce those varieties best suited for exportation, as has been done, under the encouragement of American shippers, in the islands of Jamaica and Antigua, and on the Central American coast.

The engineering development of the island must, as has been indicated, be primarily in the utilization of the unparalleled water power which is everywhere available for conversion into electric energy and will require transmission to but comparatively short distances. Through this and the great abundance of road metal, building stones, lime and clay; the construction of electric tramways, of highways and of bridges will be greatly facilitated and enormously increased in amount in the near future.

The business opportunities awaiting development are therefore of two kinds: Those which will attract the exporter of fruits and other tropical vegetable products, and those which will attract the builder of railways. In the latter direction many excellent opportunities must be found for the building up of cities or even of seaports and boom towns, and money making projects will undoubtedly soon be exploited in large numbers. Nothing of this sort can as yet, however, be successfully undertaken until such laws have been made and such government provided by the United States Congress as will secure land titles, give a stable monetary system and, especially, will relieve the exporter and importer of onerous duties and taxation. Already several important engineering projects have been examined by American capitalists. Because of the lack of good harbors, a project is now

on foot for the improvement of the most promising natural harbor, Jobos, just south of San Juan, and a boom town site is already being surveyed in the expectation of making this the commercial port of the island. Another project is the tunnelling of the narrowest portion of the central mountain range near Cayey, with a view to diverting the abundant waters of the Rio Plata to the south slopes back of Guayama and Jobos, the diverted streams there to be used in generating electric power and in irrigating the semi-arid but fertile lands. One syndicate is already in the field, and their engineer and lawyer have acquired several water rights of 500 horse power and two of 1,000 horse power on the head waters of the Rios Plata, Manati and Arecibo. Thus, while the field for the development of the engineering resources of the island is large, it has already been cursorily investigated.

The engineering possibilties of Porto Rico may be divided into the following distinct classes: First, those which are of a public nature; as the improvement of harbors, of the water supply sanitation of cities, and of the construction of highways, the latter presumably by local rather than central government; and, second, those which will be undertaken by private resources; as the building of railways and the development of water powers.

In regard to public works, harbors come first in importance. The most improved harbor and the only safe one is that of San Juan. This is land locked and is safe for vessels drawing less than 25 feet of water. The bar, however, is treacherous and the channel across this and entering the inner bay is difficult to navigate. It is now said to be 30 feet in depth, but it is so tortuous that the old transatlantic liner "Berlin," drawing 27 feet, has touched in crossing the bar, and is very difficult to bring in. The area of deep water in the inner bay is moreover comparatively restricted. This is the only harbor on the island in which the depth is sufficiently great, close inshore, to permit vessels to tie up to or unload at wharves or moles. The harbors of Ponce and Mayaguez are little more than open roadsteads. Ocean-going vessels are compelled to anchor at least half a mile or a mile away from the shore and must be unloaded by lighters. Neither harbor is safe in very stormy weather. Three excellent natural harbors are those of Puerto Real de Cabo Rojo, at the southwestern extremity of the island, Guanica, which is west of Ponce, and Jobos which is east of Ponce. All of these are land locked and perfectly safe harbors of refuge. Detailed surveys will develop which is the best,—at present Jobos is preferred. Unlike the conservative Span-

iard, the American will undoubtedly create new cities at whichever of these harbors may prove to have the safest entrance, the largest area of deep water, and especially the advantageous transshipment of freight directly from wharves instead of through the agency of lighters. In this connection there is a field for private enterprise outside of governmental harbor improvement, and an opportunity for creating commercial centers and inland transportation routes, as has been done at Aransas Pass in Texas, at Newport News, Virginia, and at other places in the United States.

Highway construction must be pushed immediately and rapidly, if any development is to take place in the agricultural industries. Roads will doubtless be built, to some extent, as public works, but under the circumstances much construction of this sort may be expected by Americans who becoming possessors of coffee and other plantation lands, and by those who, constructing railways, need the highways as feeders.

The greatest development in private engineering enterprise is necessarily to be looked for in the building of railways. These will undoubtedly be operated by electricity generated by water power. The writer fully agrees with the conclusions indicated by Mr. Lluveras in his article in the February number of THE ENGINEERING MAGAZINE. The need of these railways is crying. The conditions are favorable, and the promise of return is rich. Construction of electric tramways will be relatively little more expensive than that of such properly macadamized highways as must be built to withstand the eroding action of the heavy rains. The maintenance of these will be perhaps even less expensive than that of a properly surfaced wagon road. A central arterial system extending approximately from the eastern to the western extremity of the island on the higher slopes of the hills, but not at greater elevation than the various passes, is feasible. Such a system should have feeders or branch lines extending both to the interior towns on either side and to the shipping ports on the coast. Such a line will encounter no serious obstacles in construction. The hauling from the coffee plantations will be chiefly down hill from the higher summits to this line, which will approximate an elevation between five hundred and fifteen hundred feet, and the bulk of the heavy traffic will be over this line, also down-grade to the coast. At various points on the route of such a railway are unsurpassed water powers which will furnish not only electric energy for running the tramways but also motive power for the handling and cleaning of coffee and for the grinding of sugar cane.

As has already been shown, the south side of the island is comparatively arid. Great areas are either not under cultivation, or such agricultural products as are grown produce but relatively small crops as compared with the capacity of the fertile land. On this side of the island irrigation is casually practiced by the larger sugar planters. There are several important irrigation ditches between Salinas, Ponce and Yauco, from which water is now derived. Large amounts of land may, however, in the future be brought under intense cultivation by utilization to the full of the water resources in irrigating the fertile south coast lands.

Among the more important public works which must be immediately undertaken and which may yet in part furnish a field for private enterprise, is the providing of proper water supplies for the various cities. At present all of the cities of the island receive their water supply either from rain caught in cisterns or from gravity supplies of small amount and piped to only a few of the more important streets and buildings. The latter is the case in Ponce and in Mayaguez, while there is being completed for San Juan a fairly satisfactory gravity supply which is pumped from reservoirs a few miles outside of the city. Streams discharging sufficient volumes of potable water are found within easy access of all of the more prominent cities, and there appear to be no engineering difficulties connected with intercepting such waters and conducting them to the towns and with distributing the same in accordance with modern methods. Rarely, if in any case, will pumping be necessary, gravity being probably in every instance capable of giving all the pressure desired.

The sanitary condition of the cities of Porto Rico is at present far below the standard accepted by Europeans, and much must be done to improve it in order to make the island safely habitable by our people. Under the present American régime much has already been done to better the conditions. The more important streets in all the cities have always been fairly well paved under Spanish rule. Their surface slopes are good, and the gutters well constructed. In all of these cities surface drainage of rainfall is employed exclusively, no underground sewer systems being in existence. The more liquid portion of house sewage is also discharged into the streets, and flows through them in the open gutters, generally evaporating before it has gone very far. Fortunately on the rainy side of the island the streets are so often flushed by nature as to keep them fairly clean. The danger points are in the suburbs, where the street washings collect, and especially in the interior courtyards of the buildings, into which house

drainage is discharged and collected in cesspools. These cesspools are invariably foul and are the breeding places of all tropic diseases. They must be abolished, and house sewage and drainage be carried off in underground sewers to be chemically treated or otherwise disinfected before being discharged.

The climate of Porto Rico is comparatively healthy and with proper sanitary precautions should furnish as satisfactory a living place for Europeans as almost any other warm country. The slopes of the land are steep and the soil porous, and on the dry side of the island especially it should be possible for Europeans to live in perfect safety.

The æsthetic side of the island must not be overlooked. Its development will undoubtedly have great influence upon its future. With proper sanitation in the cities, Porto Rico should be an ideal winter resort, for it is naturally one of the healthiest of tropical countries. The mountainous interior is exceedingly picturesque, and will, with proper encouragement, soon attract a large population from the United States. This will consist chiefly of people of large means who will go there to invest in coffee and fruit properties in the mountains and to live on their plantations in the winter. This is the season, moreover, when their presence is most necessary, as coffee is picked, fruits are gathered, and sugar is ground between the months of November and March. Thus absence of proprietors during the summer will entail little risk of loss. Such people will have their horses and carriages, and will enjoy driving in the cool evenings to view the magnificent scenery. Thus their presence will encourage the construction of good highways and the building of electric tramways.

THE EFFICIENCIES OF STEAM BOILERS AND FURNACES.

By R. S. Hale.

THE chief difficulty in discussions of boiler efficiency and boiler economy has hitherto been, if one may say so, that they have been too practical. The subject depends on so many factors that experiments which determine only the practical efficiency give no light on the factors that govern this efficiency, or on how this efficiency may be improved, and as Prof. W. C. Unwin once said in effect before the Institution of Mechanical Engineers, what is needed is, not more boiler tests but a little more practical theory. When it is remembered that the combustion, the air supply, the area of heating surface, its condition as to cleanliness, its arrangement, and the external radiation, all affect the efficiency of the boiler, it is seen that the problem is not a simple one, and in the following paper an attempt will be made to state the relation of the different factors that go to make up the efficiency of a boiler as a whole.

The object of the boiler is to transfer the latent heat, or chemical heat existing in the coal into the heat of the steam. Beginning with the coal, we find that it is composed chiefly of carbon and hydrogen, and a few other elements which are comparatively unimportant. The carbon and hydrogen when burned with the oxygen of the air develop heat, and the amount of heat depends on the product formed. If the coal is burned completely, it develops as much heat as is possible, but, in practice, certain portions of the coal either do not burn at all, or burn to compounds which are still combustible, and therefore have not given up all the heat that they possibly can. The result is, that of the total heat originally latent in the coal a certain portion becomes sensible heat, while a certain other portion does not burn, and remains in the form of latent or chemical heat in the ashes, or in the products of combustion. The loss by this latent or chemical heat which never develops into sensible heat is known as the loss by incomplete combustion, and is the first, though not the most important factor on which the efficiency of the boiler as a whole depends.

After as much as possible of the latent or chemical heat has been changed into sensible heat, the next step is to transfer as much of this sensible heat as possible through the wall of the boiler into the steam,

and it is obvious that the amount of heat thus transmitted depends on the rate at which it flows through the walls at different points as the gases pass to the chimney, and also on the length of time the gases remain in contact with the different portions of the walls. The rate at which the heat flows at any given moment depends on the temperature of the gas at that moment, but after the first moment the gases begin to cool so that the rate of transmission is not constant. The initial temperature, however, and initial rate of transmission depend on the amount of air that has been used to develop the heat, for instance, if one pound of air has been used to develop 1,000 thermal units the temperature should be greater than if two pounds of air had been used to give the same result. The initial temperature of the gases depends therefore, on the amount of air used, but the moment the gases transmit any heat through the heating surface their temperature falls, so that if the initial temperature was, say, 2,000 degrees, then as soon as they have remained in contact with the heating surface for a given interval the temperature would fall say 500 degrees to 1,500 degrees. This fall of temperature will diminish the rate at which the heat flows through the heating surface, so that during the next interval of time, and while the gases are in contact with the next portion of the heating surface, the temperature will not fall as much as before, but will fall to perhaps twelve hundred (1,200) degrees only, and the lower the temperature falls the slower will be the rate of transmission of heat. In addition to diminishing the initial temperature, an increase in the amount of air used diminishes the time that the gases remain in contact with the heating surface. For instance, if twice as much air is used, each pound of air remains in contact with the heating surface only half as long. Another factor that governs the rate of flow of heat from the gases into the steam is the condition of the heating surface, and if the heating surface is covered by soot or scale, the rate of flow will be less than if it is clean.

It should be noted however, that inefficient heating surface, or excess of air does not have the same effect in every case; thus, if we have a heavy scale over all the heating surface, the transmission of heat through the part of the surface where the gas first strikes will be very much diminished, and in consequence the temperature of the gas will not fall as much as if the heating surface had been clean, and when the gas strikes the next portion of the heating surface, the higher temperature of the gas will largely make up for the higher resistance of that part of the heating surface to the transmission of heat. The same general principle applies when we consider the effect of a change

in the quantity of air. If there is an excess of air, which diminishes the initial temperature and in consequence the initial rate of transmission of heat, then the temperature will not fall so fast, and since excess of air not only makes the initial temperature low, and the transmission of heat slow, but also gives the gases less time in contact with the heating surface, it may happen in certain cases that after excess of air has caused the initial temperature to be low so much less heat is transferred to the steam that the gases when they finally leave the boiler may be even hotter than would have been the case if the air supply had been less, and initial temperature had been higher. This is a rather curious result, but has been shown experimentally as well as theoretically.

It is obvious that the ill effects of excess of air, or inefficiency of heating surface will come into play much less when the heating surface is ample than when it is small, since, if, for example, ten or fifteen times the heating surface per pound of steam would be provided, the diminished transfer of heat through the portion of the heating surface that is first in contact with the gases will be balanced by the increased transfer as the later portion of the heating surface due to the higher temperature at those parts, whereas, with a very small amount of heating surface the diminished transfer at first would not be balanced and would necessarily result in a loss. In a similar way it may be shown by theory and by experiment that if the air supply per pound of coal be very small and the heating surface be very efficient, then so much heat is taken out by the first portion of the heating surface that the total amount of heating surface is a matter of comparatively small importance.

This explains the widely divergent results sometimes obtained by boiler tests to determine the efficiency at different rates of evaporation. A series of tests is run at different rates of evaporation and if the air supply per pound of coal is small, forcing the boiler makes but little difference, or indeed if the firemen should happen to use less air per pound of fuel when the boiler is forced, the result on the forced test may even show better efficiency. On another series of tests, however, the air supply per pound of coal may be greater, and then the amount of heating surface become very important, and forcing the boiler will reduce the efficiency to a low figure.

Continuing with the history of the heat, we find that after the heat has been transferred through the heating surface into the steam, the only further loss is the loss from radiation. This has often been reported as being 5 per cent. to 15 per cent. or even more of the heat,

but as will be shown below, this has been on account of erroneous deductions from the test, and as a matter of fact the loss by radiation is probably not over 1 per cent. in well covered boilers. The heat put into the steam less the heat lost by radiation from the boiler itself gives the measure of the performance of the boiler. Any further loss is chargeable against the steam pipe, or engine, and not against the boiler.

So far I have given only a history of the heat from the time it is in the coal until it can be utilized in the steam, but the methods of tests by which these factors are measured is fully as important as their history. If we begin with the loss by incomplete combustion, the most obvious way is, first to analyze the coal and test it in a calorimeter, then to analyze the flue gases, and from these data to determine what portion of the gases is still capable of giving up heat, and how much. The difficulty of this method is purely experimental. The combustible portion of the flue gases consists of hydrocarbon compounds, and of CO (carbon monoxide). The CO can be determined fairly well, but the hydrocarbons exist in very small quantities and in many different forms and one-tenth of one per cent. of many of these forms is a serious matter, for it corresponds to three or four per cent. or even more of the heat of the coal. There is no practical method of flue gas analysis that will determine the amounts with this degree of accuracy, so that the only way to determine the loss by incomplete combustion is to determine the amount of heat originally in the coal, to subtract from this all the other heat developed, and then to charge the difference to incomplete combustion.

An analysis of 103 tests on different types of boilers indicated that the loss from incomplete combustion to hydrocarbons varied from one per cent. to twenty per cent. and probably averages about seven per cent. while the loss from incomplete combustion to CO varies from nothing to twenty per cent. and probably averages about one-half per cent. or one per cent.

The loss of sensible heat in the flue gases can be determined reasonably well from the gas analysis and the temperature of the gases, since the gas analysis and the coal analysis enable us to compute the amount of gas per pound of coal; and from this figure, from the temperature and from the specific heat the total heat units carried away in the gases can be computed.

Of course if there is leakage into the flue after the gases have left the boiler the effect is to reduce the temperature of the gases and to increase their amount without changing the amount of heat in them,

so that the measurement of the actual loss of the sensible heat in the flue gases is not affected, nor is the efficiency of the boiler affected by such leakage. On the other hand, leakage through the setting before the gases have left the boiler reduces their temperature, and in consequence the amount of heat that they can transmit to the walls at the latter portion of the heating surface, and therefore reduces the efficiency. In both cases however, the measurements of the gases and their temperature shows the loss in the flue for that particular test. It may be however, that no inference can be drawn as to other tests with different amounts of air leakage, since if there has been leakage at any point, the gas analysis does not show the amount of gas that has been in contact with the heating surface, so that in case of air leakage the application of the theory of the flow of heat may give erroneous results. Analysis of tests shows that the loss of sensible heat in the flue gases varies from ten per cent. to thirty-five per cent., and averages about twenty per cent.

The loss by radiation cannot be determined from the boiler test itself, and must be determined by a separate experiment which is possible only in certain types of boilers, and even then is a matter of some difficulty. In general it is not determined separately, but the balance left after subtracting the heat in the steam and the heat in the gases from the heat originally in the coal includes both the loss by radiation and the loss by incomplete combustion. In such case the boiler test itself gives no indication of how much heat should be ascribed to each of these two losses, but a comparison of a great number of tests has shown that in the great majority of instances the radiation loss is but small, and that most of the unaccounted for heat has been lost in the form of incomplete combustion.

From the results of the same tests above referred to, it has been shown that the radiation loss from well covered boilers probably averages one per cent.

All the heat not lost in the form of incomplete combustion, as sensible heat in the gases, or as radiation, is available as heat in the steam, and the tests showed that the percentage of heat thus available varies from 50 per cent. to 87 per cent., averaging about 71 per cent. We may therefore state an average heat balance according to the accompanying table.

This analysis indicates the method that should be used in judging the results of tests of boilers or their appliances. For instance, if the radiation loss on a boiler is one per cent., a device applied to diminish the radiation can only save one per cent. If the loss by

incomplete combustion is only seven per cent., a device to give complete combustion can only save seven per cent. at the best. In comparing two tests it is necessary to know not only that the boiler and the furnace are the same, but it is necessary also to know what the different factors were that made up the results in each case. For instance, a complete combustion device is applied and tests show that the efficiency of the boiler which was formerly 70 per cent. is now 77 per cent. Nevertheless, it is entirely probable that the saving was not due to the

Lost in incomplete combustion to hydrocarbons....	7
Lost in incomplete combustion to carbon monoxide	1
Lost in sensible heat in flue gases.....	20
Lost in radiation.....	1
Available in steam.....	71
	100 per cent.

The best performance on record is a test on a Thorneycroft boiler by Professor Kennedy which gave:

Incomplete combustion to hydrocarbons, and radiation	1.9
Incomplete combustion to carbon monoxide.	0.5
Sensible heat in the flue gases.....	10.8
Available heat in the steam.....	86.8
	100 per cent.

device at all, but that on the second test the amount of sensible heat lost in the flue gases was diminished by seven per cent. through some slight and almost unnoticeable variation not connected with the device, while the loss by incomplete combustion remained the same. Thus although consideration of the efficiency alone might have indicated a saving, the complete tests show the device to be absolutely ineffective.

These methods of analysis may be applied to a question often discussed, namely, does heating the feed water by live steam from the boiler result in a saving of coal? It is obvious that heating the feed water cannot affect the efficiency of combustion of the furnace, nor can it affect the air supply per pound of coal. It is possible, however, that heating the feed water might, by improving the circulation of the boiler make the heating surface more efficient in transmitting the heat. If, therefore, we apply a live-steam heater and find that the efficiency of combustion (as shown by the heat balance) and the air supply per

pound of coal (as shown by the gas anaylsis) remain the same, but that the heating surface takes more heat out of the gases than before, (making their final temperature lower) then we may fairly ascribe the saving to the live-steam heater. Unless, however, we know that the efficiency of combustion and the air supply are the same there is no means of telling whether the saving was due to the live-steam heater, or to some other cause.

Although we may understand clearly the process by which the latent heat in the coal is transferred into the heat of the steam, and may know how to measure the different losses that occur in this process we cannot determine the best methods of running and building boilers except by making tests and comparisons of the many different types of boilers, and the different methods of running them. A series of such tests to be complete would involve thousands of trials at an expense which would run up in the tens or even hundreds of thousands of dollars, and no single boiler manufacturer or single oragnization of any kind can afford such an expense. The only method therefore is to take such tests made from time to time as are reasonably complete and accurate, and to draw such conclusions from them as we can. This is a work which I have performed in a paper before the American Society of Mechanical Engineers, and without going into the detail of the different computations, I shall give the general results which are as follows:

1st. In regard to radiation. The radiation depends only on the temperature of the outside of the boiler, so that the radiation when expressed in heat units should be nearly a constant amount, and the percentage that this amount bears to the total heat should diminish if the boiler is forced and the total heat increased. When, however, the results of tests on a great number of boilers were compared it was found that the percentage of the unaccounted for heat averaged about 9½ per cent. whatever the rate of working, instead of varying when the rate of working varied, as would have been the case if the unaccounted for heat had been radiation. It was therefore clear that the radiation itself was very small in amount and that the unaccounted for loss must be due to some other cause, probably incomplete combustion.

It was important to determine what were the causes of incomplete combustion, and this was very difficult, since an error in any measurement affected this amount, and as a result the loss by incomplete combustion appeared to be very capricious, sometimes very high, sometimes very low. When, however, I omitted incomplete combustion to CO and considered only incomplete combustion to hydrocar-

bon I found by analysis and comparison of the tests a valuable indication. Whenever the conditions were such that the fire and the initial temperature of the gases were very high, the loss by incomplete combustion was very low. For instance, when the rate of combustion was very high, giving as is known by experience and has been shown by tests a very hot bed of coals, the incomplete combustion was low. When the rate of combustion was low the loss by incomplete combustion was high. When the fire was surrounded by hot brick walls, the incomplete combustion was low. When the fire was surrounded by the cold walls of the boiler itself the incomplete combustion was high. The results of individual tests were very capricious, but the general tendency was strongly in this direction, and further proof will probably be obtained when further experiments are made, and made with the necessary accuracy.

Loss by incomplete combustion to CO when measured directly turned out to depend closely on the air supply. If the air supply was less than one hundred and fifty per cent. of that theoretically necessary the CO loss began to appear, but several tests showed that with skillful firing the air supply could be brought down to and below this point without causing a serious amount of CO to form.

The loss in the flue gases depends on the amount of air used, on the evaporation per square foot of heating surface, and on the condition of the heating surface. The evaporation per square foot of heating surface is easily controlled, although in certain types of boilers the results clearly indicated that the gases short circuited and never came in contact with portions of the heating surface. Of course, this renders such portions ineffective, and throws more work on the rest of the boiler. The condition of the heating surface is also easily controlled by keeping it clear of soot on one side, and scale on the other. The amount of air however, depends on many uncertain factors. Comparison of many tests showed apparently that one of these was the rate of combustion per square foot of grate, and that if the coal was burned slowly say, less than 15 pounds of coal per square foot, per hour, the amount of air per pound of coal used was high, while if the coal was burned at a high rate, say, 30 pounds per square foot per hour, the amount of air used per pound of coal was low. The results of course, were capricious, there being tests on record which showed that a skillful fireman could burn the coal slowly and yet use only a small amount of air, and there is an indication that it is the ratio between the rate of combustion and the draft pressure that determines the air supply and not the rate of combustion alone. We will take up the question of

draft pressure later on, while we note here the interest of this fact which shows the cause of an opinion that exists in some quarters that boilers will not give the best results unless forced to a certain extent. The theory indicates, and we should naturally expect, that the more coal burned per square foot of heating surface the less would be the efficiency of the boiler. If, however, burning a large amount of coal per square foot of heating surface means also burning a large amount of coal per square foot of grate, the higher rate of combustion per square foot of grate will often coincide with a reduced air supply per pound of coal and in consequence the loss in the flue may be reduced sufficiently to balance the loss due to forcing the heating surface, so that the boiler when forced may be considered as a whole to show a better efficiency than when run at a moderate rating. This of course, would not be the case if the area of grate surface was reduced so as to burn the coal at a high rate of combustion without forcing the heating surface.

We will now return to the question of draft pressure and note that certain facts indicate that it is the ratio between draft pressure, or rather the square root of the draft pressure, and the rate of combustion that governs the air supply per pound of coal rather than the rate of combustion alone. The laws of hydraulics indicate that the total air supply should vary as the square root of the draft pressure. If, then the draft pressure is higher than is necessary to burn the coal at the desired rate, the air supply will be in excess and the loss in the flue large. Now the draft pressure available generally depends on the chimney and is frequently constant for all substantial purposes whatever the rate of combustion, so that unnecessarily high draft pressure, in proportion to the rate of combustion, and consequently excess of air supply would happen most frequently with low rates of combustion; and moderate air supply would accompany high rates of combustion.

The comparison of the results of the tests showed also that in certain types of boilers a great amount of air leaked into the gases after they had cooled down below the point of combustion, and that in some cases this leakage reduced the efficiency by as much as 10 or 15 per cent. Of course this loss does not occur in other types of boilers where it is impossible for such leakage to occur.

We, therefore, find that from the point of view of economy of coal, leaving out questions of safety, ease of management, first cost, etc., that the good boiler should have a large furnace lined with firebrick where the temperature of combustion will be as high as possible, and thus the incomplete combustion will be as small as possible. In

this furnace a small grate should be provided on which the coal should be burned at a very high rate of combustion, 25 or 30 pounds per square foot. It is not practical however to go much beyond this rate, as unburned coke, coal and cinders will be carried up the chimney by the strong draft necessary if too high a rate of combustion is used. After the coal is burned in such a furnace the gases should be passed over a large area of heating surface, and this heating surface should be so arranged that no air can leak into the gases after the gases have passed into the flue.

Some of these conditions are incompatible with convenience of management, cleaning, low first cost, etc. For instance, the condition that there must be no air leakage either shuts out the water tube boilers and their acknowledged safety from any very destructive explosion, or else it involves bent tubes of the Thornycroft type which are hard to clean, or else it involves an air tight casing which is expensive. All these questions are beyond the province of the present paper. I have aimed only to show the factors that cause high efficiency, but have not tried to discuss the cases in which it is worth while to sacrifice other advantages in order to obtain high efficiency.

THE GREAT MAGNETITE DEPOSITS OF SWEDISH LAPLAND.

By David A. Louis.

SOME fifty miles directly north of the Arctic mining town of Gellivare, in Swedish Lapland, and about double that distance by road and river, is situated, at a latitude of 67° 57′, that remarkable range of heights known by the names of Kiirunavaara and Luossavaara. The position of this range of heights in relation to Gellivare and to the railway projected to connect them with that town in one direction and with the Norwegian frontier and seaboard in the other direction, may best be gathered by reference to the map, Fig. 1. This railway is to be single track, with crossings at the places marked by a circle on the map, and stations at Kiirunavaara-Luossavaara, at the frontier, and at Victoria Havn, in Norway; it

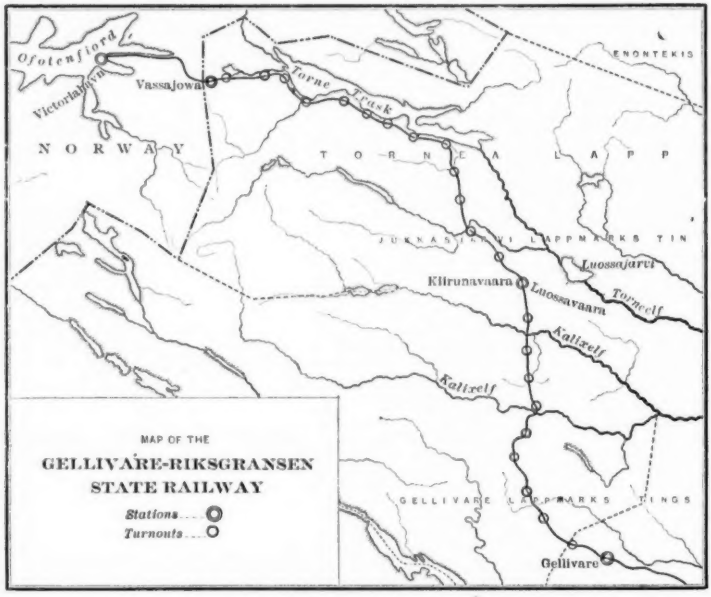


FIG. 1. SKETCH MAP OF SWEDISH LAPLAND.

FIG. 2. THE ROAD TO LUOSSAVAARA.

will make the distance from Gellivare 65 miles, from Lulea 188½ miles, to the frontier about 82 miles, and to Victoria Havn, on Ofoter Fjord, 107⅓ miles.

The range of heights in question is remarkable for the fact that the summits of the heights and the intervening ridges consist of a nearly unbroken outcrop of magnetic iron ore, an incident that had already attracted attention 200 years ago; and spasmodic attempts have from time to time been made to utilise this vast store of useful material, but without achieving any measure of success. This is not to be wondered at when one has made the acquaintance of the country and its roads. The country has climatic disabilities, and, moreover, consists mainly of swamps, marshes and lakes, with a few hills here and there. There is but scanty vegetation, thin forests of stunted trees, with an occasional birch or pine towering above like a giant in an assembly of dwarfs, and mossy and scrubby growth elsewhere. It is not the sort of country to attract a population, and as a consequence good roads are not wanted and are not to be found. At the present time, Kiirunavaara and Luossavaara are accessible from Gellivare by a route, the first stage of which is a very indifferent road, some 40 miles in length, touching on the way the small settlements of Murquivaara and Maskujäni, and terminating at Lappeasuando, on the Kaliz river. This river may be ferried and the journey be continued by road, but it

Kiirunavaara. Luossavaara.

FIG. 3. PANORAMIC VIEW OF THE RANGE, FROM THE NORTHEAST

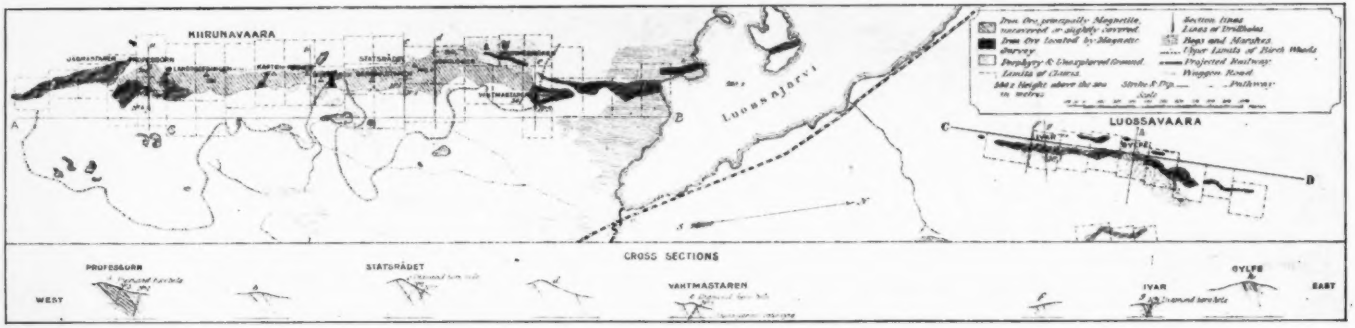


FIG. 4. MAP OF KIIRUNAVAARA AND LUOSSAVAARA IRON-ORE FIELDS.

is preferrable to take the boats or canoes and folks of the country and proceed up river. This is a broad stream of water, with a remarkable irregular bed, along which is distributed at frequent intervals a plentiful supply of boulders of varying sizes, so that with two passengers in a boat and three men to work it, paddling, sculling, poling and towing according to circumstances, the journey up stream proves a very laborious task, not devoid of excitement. Although only 40 miles has to be covered in this way it takes about two days to accomplish it, there being many stoppages for the men to rest and refresh, and in our journey Kiviniemi, the only inhabited place we passed, was made the halting place for the night. Homojänka is the landing place for Kiirunavaara, and thence a new road, 10 miles in length, leads to the little settlement that has risen around this scene of pioneering activity. Fig. 2 shows the new road at the approach to this destination, with the houses in the mid-distance, Lake Luossajärvi on the left, and the fine hill Luossavaara in the background. This, then, does not strike one as being a mode of transport suitable for the heavy traffic incident to iron mining, in spite of the fact that the journey down the river is done in eight hours.

It has been fully realised for a great many years that better communication should be had, but various obstacles have stood in the way of effecting any improvement. Ultimately, however, these have been removed, mainly by the energetic persistency of Consul G. E. Broms. Parliamentary powers have been obtained for the construction of the railway, which is to be completed within four or five years, and by that time, if we may judge from present state of things, all will be ready at the mines to get to work in earnest.

The district, as may be inferred from remarks that have already been made, has been the scene of may investigations, but the most thorough has undoubtedly been that conducted under the auspices of the Swedish Governent by Mr. Hjalmar Lundbohm, who too has already given to the world in a special brochure and in an epitomised form in a paper before the Iron and Steel Institute (Vol. II., 1898), an account of some of the investigations that have been made at Kiirunavaara and Luossavaara. From these publications the following figures are borrowed. Fig. 2 is from a photograph sent the writer by Mr. Lundbohm. Fig. 3 is a panoramic view, obtained from the south-east, and shows the relative position and magnitude of the various prominences, which have been named to designate the various officials and assistants who have had a hand in the pioneering work. As a gauge of the size it may be noted that Statsradet is about 816 feet,

FIG. 5. ELECTRIC TRACTION IN OPEN-CAST WORKINGS.

Grufingenioren 584 feet, Bergmästaren 715 feet, Kapten 676 feet, Landshofdringen 781 feet, Professorn 783 feet, Jägmästaren 679 feet, and Luossarvaara about 751 feet above the lake Luossajärvi, which is about 1,640 feet above sea-level.

Fig. 4 furnishes the map of these deposits and their surroundings, and much information may be gathered from simple reference to it—that is, with the help of the conventional markings. Firstly, it will be observed that from the extreme south point of Jägmästaren to the continuation of the deposits on the island in Lake Luossajärvi indicates a practically unbroken stretch of nearly 3 miles of ore deposit in the Kiirunavaara range. The total length of the ore-body on Luossavaara is computed at 4,165 feet, and it does not appear to be connected with the Kiirunavaara deposit. Next it may be observed that the width of the latter deposit or deposits appears to vary from about 100 to 836 feet, while the deposit at Luossavaara does not appear so wide, the maximum width being about 200 feet. I say apparent width because as a matter of fact the actual width of the deposits is not as great as it appears on the surface, this exaggeration being due to erosic effects and the dip of the deposits.

A considerable proportion of the outcrop is freely exposed and

open to view, so that a walk over the ground gives one every opportunity of verifying the character of the material comprising the ridge and summits, while the existence of further non-exposed extensions of the ore-mass has been proved by means of the excellent system of magnetic surveying described by Professor G. Nordenström (Iron and Steel Institute Journal, Vol. II., 1898). The areas discovered in this manner are indicated on the map, Fig. 4, by cross-hatching. But the exploiters of these deposits have not restricted themselves to these means only to ascertain the character and extent of this great ore mass, for they have sunk or quarried no fewer than 184 test pits on Kiirunvaara and 14 on Luossavaara, many under the direction of Mr. Lundbohm, who in addition has directed and arranged a system of exploration by boreholes that has yielded important results, and from which still further weighty information is expected. On Fig. 4 the position and direction of the boreholes is duly indicated on the map, and in the lower portion of the figure some of the cross-sections revealed by these borings are set forth. These sections show that the deposits have a fairly constant dip of from 50° to 70° to the eastward on Kiirunavaara, and of 75° on Luossavaara the strike of the two being shown by lines A B and C D, respectively. The boreholes

FIG. 6 SELF-ACTING INCLINE IN LAPLAND.

moreover, show that there are some indications of the deposits narrowing in depth; but however that may be as far as present investigations show the thickness of the ore mass between walls varies from 111 to 498 feet on Kiirunavaara and from 98 to 180 feet on Luossavaara, and in both cases the deposits are traceable to and below the level of the lake.

The available data, therefore, point to the quantity of ore above the level of Lake Luossajärvi, amounting to some 215,000,000 tons in Kiirunavaara and 18,000,000 tons in Loussavaara; or taken together there appears to be no less than 233,000,000 tons of ore in this district

FIG. 7. MAGNETITE WITH DISSEMINATED APATITE.

above the level of the lake. There is very strong evidence indeed of large but unknown quantities of iron below that level; therefore taking into consideration the Swedish policy of moderation in mining, and the belief in the fostering as compared with the rapid exhaustion of their treasures, which it is proposed to adhere to in this instance, for the projected output from Kiirunavaara-Luossavaara is not to exceed 1,500,000 tons a year, so there are prospects of many years' activity in this inclement region. This fully justifies the construction by the State of the railway, shown in Fig. 1, and the proposed course of which through this iron district is indicated as going along the north side of Lake Luossajärvi in Fig. 4.

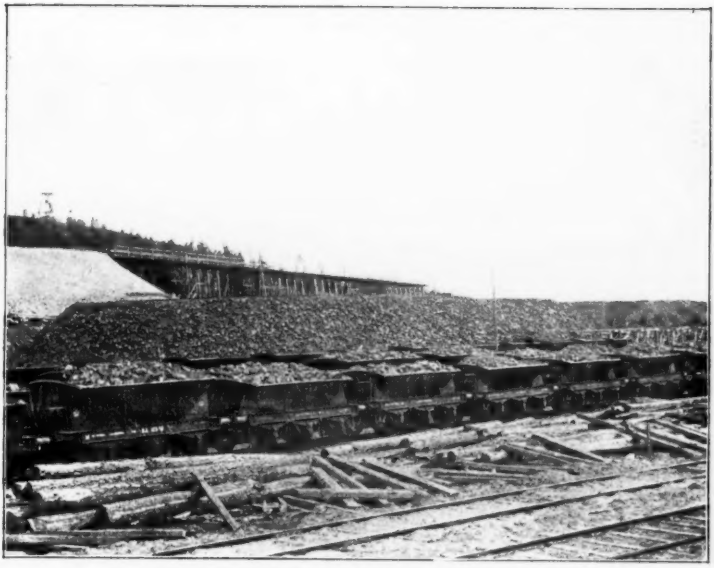


FIG. 8. TRAINS OF LOADED ORE TRUCKS, SVARTÖN.

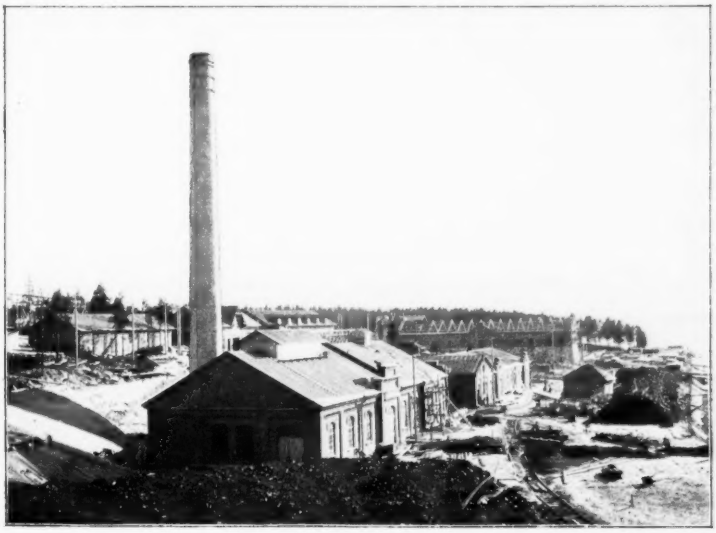


FIG. 9. ELECTRIC STATION AND PHOSPHATE WORKS, SVARTÖN.

The systematic exploratory and tentative exploiting operations that are now being conducted have still another object in view—namely, the acquisition of such knowledge as will enable the engineers in charge to form a correct notion of the best method of working these deposits. There is no doubt that very considerable quantities of ore can be obtained from surface workings and for this purpose open-casts and self-acting inclines are contemplated, such as are in vogue at Gellivare, and are illustrated in Figs. 5 and 6. The former shows electric traction applied to the transport of broken ore in trucks from the open-cast workings to the head of the self-acting incline, of the character indicated in Fig. 6, which is used to lower the trucks of ore to rail level.

A personal inspection of the surface of the outcrop and of the country; of many of the test pits and quarried faces; of the sites of the boreholes, portions of ore, and of boring operations in progress, leads to the conviction that the character and magnitude of these deposits have in no way been exaggerated or misrepresented by the Swedish engineers engaged in the investigation of the property.

Taken as a whole the deposits consist of continuous bed-like masses of massive magnetite, situated between walls of porphyry or

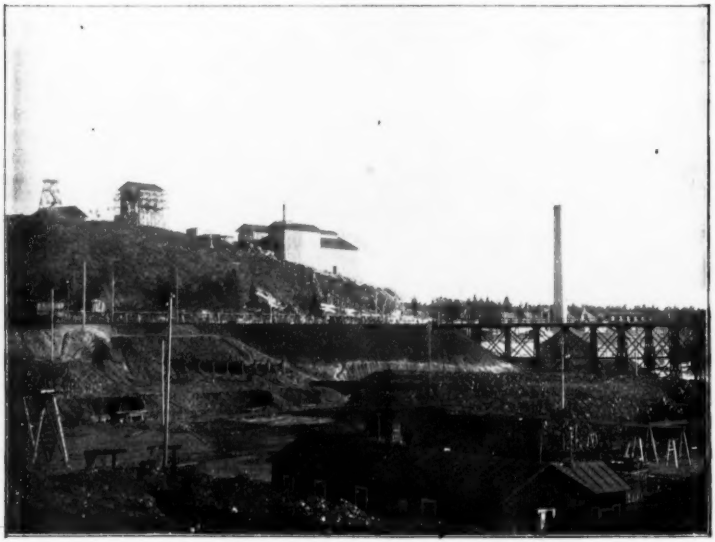


FIG. 10. MAGNETITE SEPARATING HOUSE, SVARTÖN.

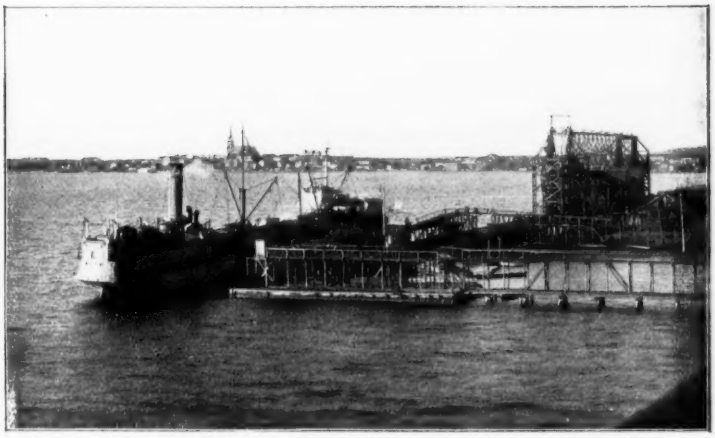


FIG. 11. ORE AND COALING STATION, SVARTÖN. LULEA IN DISTANCE.

porphyritic felsite, that varies slightly in character. The magnetite at many points exhibits strong polarity, and generally is remarkably fine-grained, compact and hard. It is, however, traversed by numerous small joints, which render it sufficiently fissile to split into small pieces when blasted, but without falling to dust as the coarser-grained ore of Gellivare is apt to do. The magnetite near the walls is somewhat mingled with hornblende and chlorite, and at other isolated spots

FIG. 12. NEW ORE LOADING DOCK, SVARTÖN.

FIG. 13. MOUNT BLAGODAT FROM THE EAST.

with fibrous hornblende; quartz, talc, malachite, yellow mica, iron pyrites or tetanite are occasionally encountered. More frequently haematite and calcspar accompany the ore, while apatite is the prevailing admixture, and contributes the proportion of phosphorus that is so commonly found in these ores. This noteworthy freedom from admixture accounts for the high percentage of iron found in samples

FIG. 14 AN OPEN-CAST WORKING AT MOUNT BLAGODAT.

taken from the numerous pits and boreholes; the numbers obtained by Mr. Lundbohm from unpicked and unsorted ore are as follows:

In	7	pits, or	6	per cent.	of	the	whole	number,	from	45 to 50	per cent.	iron,
"	11	"	12	"	"	"	"	"	"	55 to 60	"	"
"	23	"	21	"	"	"	"	"	"	60 to 67	"	"
"	26	"	23	"	"	"	"	"	"	67 to 69	"	"
"	25	"	23	"	"	"	"	"	"	69 to 70	"	"
"	16	"	14	"	"	"	"	"		upwards of 70	"	"

That is, more than 60 per cent. of the sampling indicates a percentage of iron exceeding 67, which, as a number for an ore field, and that a big one, is admittedly exceptionally good.

Then as regards phosphorus, 18 pits showed 0.05 or less, 18 between 0.05 and 0.1, 25 between 0.1 and 0.8, 15 between 0.8 and 1.5, and 32 between 1.5 and 6.0. That is, only 16 per cent. of the sampling shows the lowest proportions, such ore being encountered in workable quantities at the Vaktmästaren, Landshöfdingen and Professorn hills. The rest is generally higher phosphatic, and in fact about 30 per cent. of the sampling indicates a proportion of phosphorus coming within the highest limits. The percentage of sulphur has in a few instances reached 0.1, otherwise it never exceeds 0.088, and generally is about 0.05, or sometimes even less than 0.02. Tetanium occurs in some parts, and has been found to the extent of 0.32 to 0.95 per cent., while of manganese there is very little—that is, it is not above 0.32 per cent.

FIG. 15. A SELF-ACTING INCLINE AT MOUNT BLAGODAT.

The number given refer to Kiirunavaara, but with slight variation may be taken as representative of Luossavaara as well.

To give some further idea of the character of the ore the following numbers are given; they are the results obtained from the complete analysis of samples of sorted ore, ore from Vakmästaren on Kiirunavaara, the other from the summit of Luossavaara. The numbers are per cent.:

	Iron ore from—	
	Kiirunavaara.	Luossavaara.
Magnetic oxide of iron	96.25	71.15
Ferric oxide	1.62	25.32
Iron	70.80	69.23
Manganic oxide	0.26	0.26
Lime	0.40	0.30
Magnesia	0.31	0.22
Alumina	0.39	0.56
Silica	0.95	1.85
Phosphoric acid	0.008	0.086
Phosphorus	0.004	0.037
Sulphur	0.033	0.03

As will be seen, the composition of the ores is similar, and so is their character. A word may perhaps well be added concerning the phosphorus; it is, as I have already stated, not in the magnetite but in the associated apatite, as is the case in Gellivare. In the present instance it is sometimes distributed in segregated masses, at times forming great isolated patches, at other times making a kind of stockwerk with the magnetite, while in yet other cases it is so finely divided and evenly disseminated as to make an intimate mixture with the magnetite as shown in Fig. 7, which is a photograph of a thin section of such ore enlarged 39 times—that is, from the size of the adjoining dot. This explains the anomaly of an apparently pure ore containing as much as 3 to 6 per cent. of phosphorus.

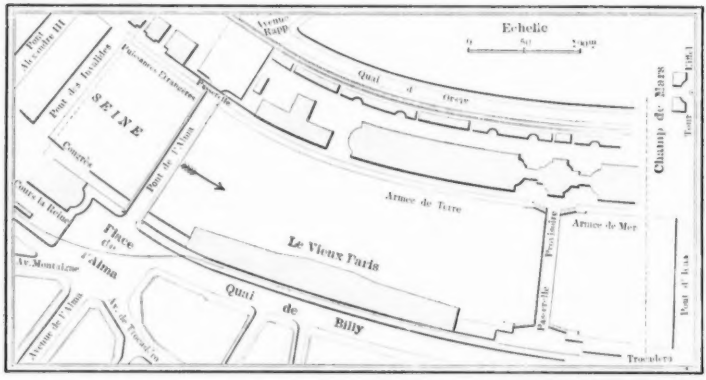
THE BUILDINGS OF THE PARIS EXPOSITION OF 1900.—II.

By Jacques Boyer.

ALTHOUGH a very notable part of the Exposition of 1900 is to arise along the shores of the Seine, we cannot at present say much about these buildings, with exception of the Aquarium, "Old Paris" and "Les Bonhommes Guillaume," which are undertakings in the nature of private concessions. We may, however, outline the various projects which will arise along the shores of the river during the coming year. On the left bank, near the Eiffel Tower, the Forestry Pavilion will be built; here also will stand the building dedicated to Navigation and Commerce, as well as the Foreign Government Buildings. A photograph taken at the present time shows that so far only the platform has been laid, while the plans elaborated by the Commissioners of each nation still await approval by the French administration. On the right bank the colonies of France and those of foreign nations will occupy the ground in front of the Trocadero. Here only the foundations have been begun. The Aquarium and "Les Bonhommes Guillaume" are not within the scope of this article, but there remains the contemplated reproduction of "Old Paris," the construction of which is sufficiently advanced to merit a passing notice. As shown on the plan, the buildings comprising "Old Paris" will extend from the bridge of Alma to a temporary passage way thrown across the river above the bridge of Jena, to provide a passage from the Army and Navy Buildings to the Quai Billy. The plans for "Old Paris" were made by the eminent artist Robida,* who has here undertaken to design, with the aid of many old documents, the most picturesque edifices of the French capital of times gone by.

By means of an embankment extending out into the Seine, the space available was enlarged to a grand total of 6,000 square metres. The panoramic view of the scheme shows the general effect, and among the actual reconstructions contemplated we may cite the Porte St. Michael, the birthplace of Molière; the Bureau of

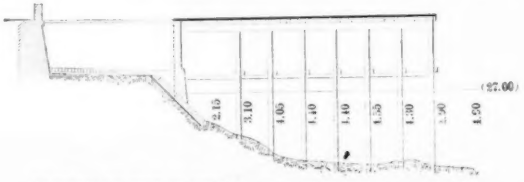
* M. Robida has kindly permitted the reproduction here of some of his designs, which courtesy we take pleasure in acknowledging.



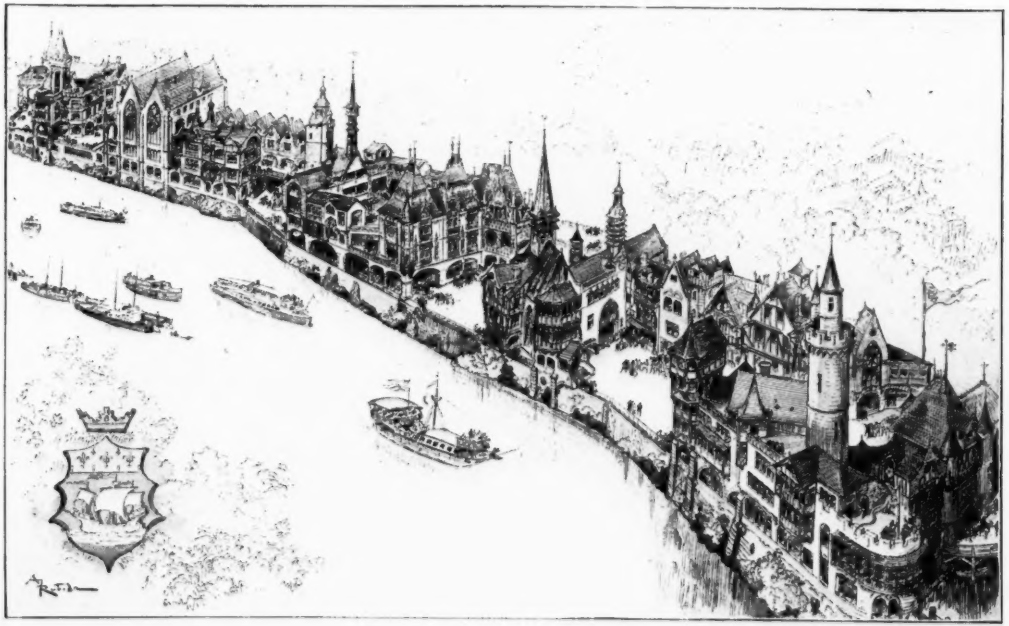
PLAN OF THE BUILDINGS ALONG THE BANKS OF THE SEINE.

Information of Theophrasto Renaudot, founder of the first French journal; the Place du Pré-aux-Clercs; and the Tower of the Louvre, the Grand Châtelet, the Rue des Vieilles Ecoles, etc., etc In a word, it is proposed to recall, in its popular, commercial, or industrial aspect, the life of Parisians during the seventeenth century, in the setting and costumes of that time.

The work of building the foundations for "Old Paris" was finished some time ago under the direction of the engineer, M. Benonville, and are sufficiently interesting to demand notice. The available area being very limited, piles were driven into the river bed in order to extend the width of the platform to about twenty-two metres. In the middle an additional projection over the river increases this width to twenty-nine metres. About 900 pine piles, one metre in circumference and from ten to fifteen metres long, were driven in the usual way, their lower ends having first been provided with a pointed wrought iron shoe to permit their being driven into the river bottom. Owing to the character of the river bed, this was an operation of some difficulty, some of the piles requiring

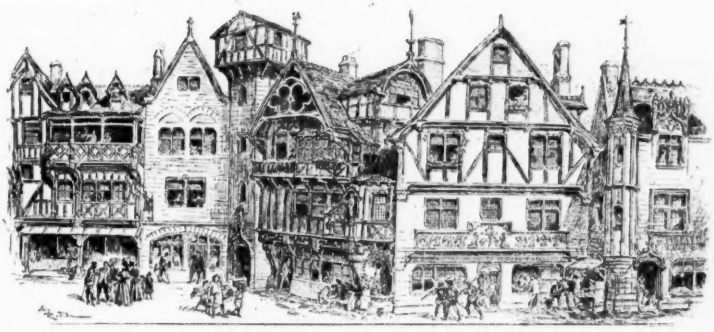


SECTION OF THE PLATFORM SUPPORTING "OLD PARIS"



A GENERAL VIEW OF "OLD PARIS."

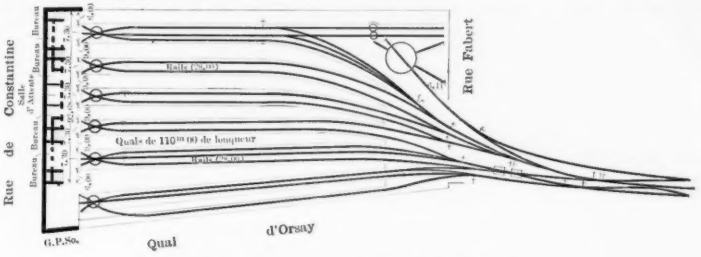
THE ENTRANCE TO "OLD PARIS," PORTE ST. MICHAEL, MARCH, 1899.



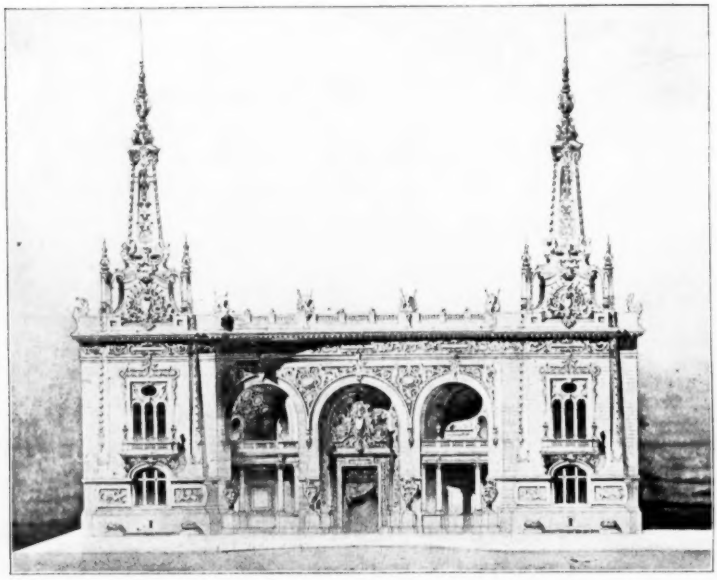
RUE DES VIEILLES ECOLES "OLD PARIS."

as many as 500 blows to be sunk a distance varying from two to six metres, according to the location.

The profile of the slope at different points was determined by preliminary surveys, the one reproduced in the engraving being about the middle of the platform, the level 27.00 being the normal datum at the barrier of Suresnes. In order to increase the stability, the piles are framed together by four courses of horizontal timbering, running longitudinally and transversely, there being a framing of riveted steel beams above and a flooring of heavy pine planks. The platform is computed to sustain a loading of 4,000 kilogrammes per square metre. This substructure alone has cost 500,000 francs. The design and decoration of the superstructure will cost much more than this, as it is the intention of the authors of the project to make the historical reproductions as accurate and artistic as possible. There is no doubt that this feature of the Exposition will be a great success, and we may venture to predict that



PLAN OF THE INVALIDES RAILWAY STATION.



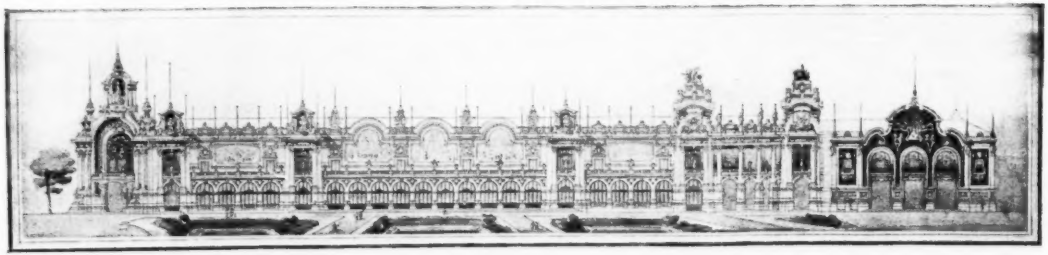
THE CENTRAL PALACE OF THE ESPLANADE DES INVALIDES.

the inns of "Old Paris" will overflow with noisy "Escholiers," rather than with grave "Docteurs-en-Sorbonne."

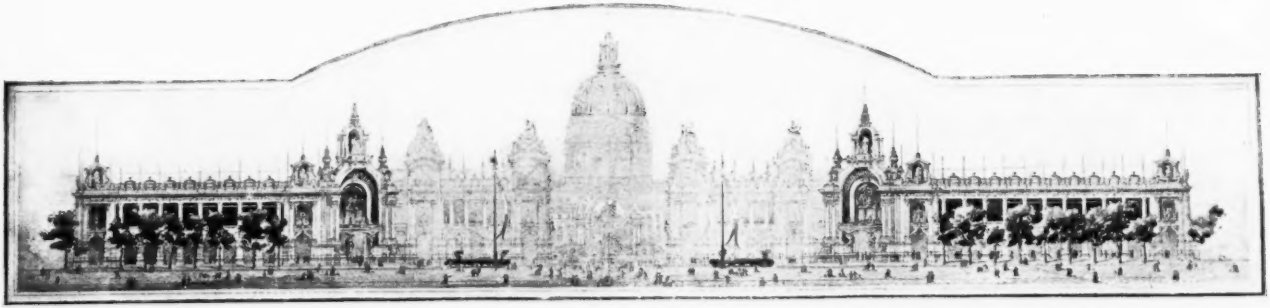
Regarding the Horticultural Building and the exhibit of the City of Paris, both of which face the pavilions ot the foreign powers, but little can be said at the present time, as their construction is not very far advanced. There will be ample time for their construction, however, as they are of a design which admits of rapid work, especially the Horticultural Building, which, in fact, will form a vast hot-house, covering an area of four square kilometres and costing 700,000 francs.

We now come to the buildings upon the Esplanade des Invalides, including the new railway station.

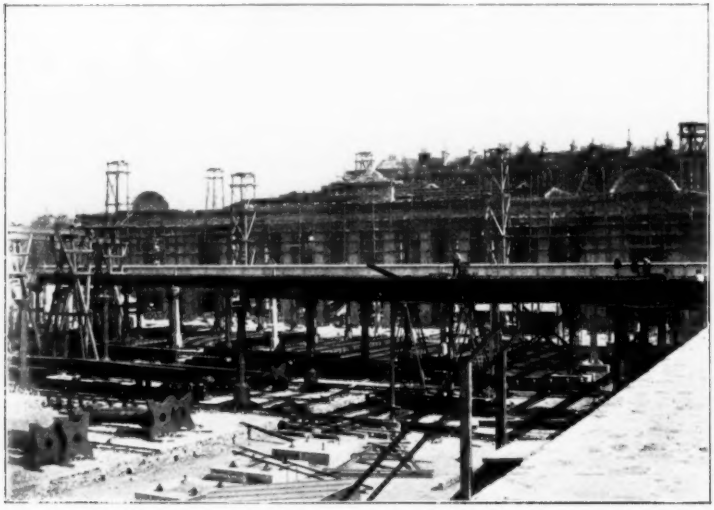
While these buildings present no extraordinary features, they offer much that is of interest, really more than we can fully describe in the limited space available. We can only mention the ingenious scaffolding and hoisting apparatus designed by the contractor, M. Leclair, and refer to the extensive plans which have been made for the improvement and decoration of the future avenue which is to form the prolongation of the Alexander III.



THE NATIONAL MANUFACTURES BUILDING



THE GALLERIES OF THE INVALIDES RAILWAY STATION.

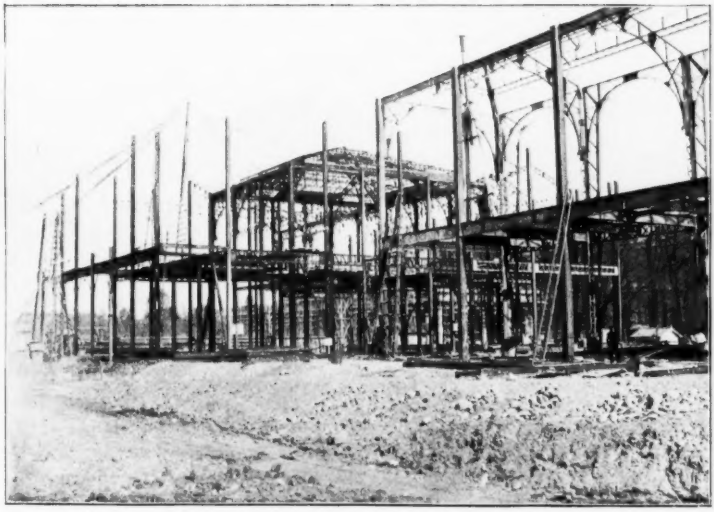


THE WORK ON THE INVALIDES RAILWAY STATION.

bridge. While these various structures have been entrusted to different architects, among whom we may mention MM. Toudoire, Pradelle, Esquié and Tropey-Bailly, the endeavor will be made to secure harmony in general effect, although designs of various styles are to be adopted.

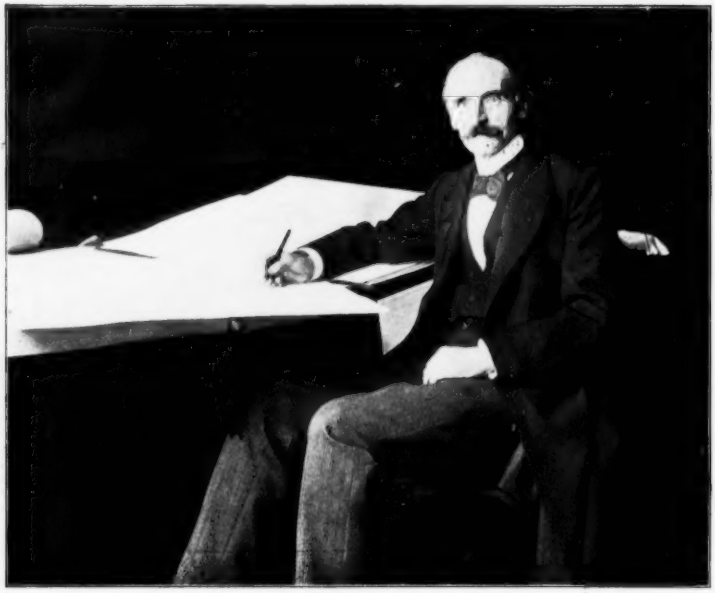
Among the illustrations are shown the National Manufactures Building and the Galleries of the Invalides Railway Station, and also a view of the latter structure showing its state of advancement in April, 1899. Most of the buildings upon the Esplanade des Invalides are to be provided with galleries similar to those in the buildings on the Champ-de-Mars, and in these galleries, to which ready access will be given by stairways, elevators and traveling platforms, will be placed restaurants and many exhibits and other attractions. The whole arrangement of these buildings compares most favorably with those of 1889, the arrangements for illumination and ventilation being far superior.

We shall now proceed to the new railway station of the Invalides. The Western Railway of France already possessed a terminal on the left bank of the Seine, by the Champ-de-Mars. This was the end of a local line connecting at Puteaux with the Versailles Railway of the right bank. It was decided some time



THE INVALIDES RAILWAY STATION, APRIL, 1899.

PLATFORM FOR THE NAVIGATION AND COMMERCE BUILDINGS.



M. ALFRED PICARD, COMMISSIONER GENERAL OF THE EXPOSITION OF 1900.

ago to move this station to a point nearer the centre of the city, and this project was hastened in anticipation of the great crowds which are expected during the Exposition. The important roadway construction works which this extension involved cannot be described here, but must be reserved for another time, and we shall confine ourselves only to the new station building.

In the design of the station it was required of the engineers that they should encroach as little as possible upon the grounds, as it was desired to avoid obstructing the fine view, while at the same time it was important to provide sufficient accommodations to meet the heavy demands of the service.

The plan view of the station shows how this problem was solved. A vast underground hall, of a mean width of 110 metres, extends for a length of 220 metres between the Rue de Constantine and the Rue Fabert, proving an area of nearly 25,000 square metres, or more than double that of the new station of the Orleans company at Quai d'Orsay. This underground station will contain thirteen tracks, with suitable platforms, of 170 metres in length.

The terminal building of the station, containing the waiting rooms, offices, etc., is situated on the Rue de Constantine, facing the Ministry of Foreign Affairs, and being but one story high and surrounded by trees will not be conspicuous. Several stairways will communicate with the underground platforms, and above ground the two wings of the building will be designed in the style of Louis XIV., in order to harmonize with the adjoining Hotel des Invalides. The subway containing the tracks will be covered with a metal platform providing a roadway of twenty metres in width, and forming on the left a continuation of the Alexander III. Bridge, the openings for the railway beneath being screened by the foliage of small gardens.

In this rapid survey of the buildings of the Exposition of 1900 we have necessarily passed over many things which, while attractive in themselves, would demand too much space to describe here. Among these we may name the gigantic telescope, the building of the Alpine Club, "French India," "Andalusia in the time of the Moors," and others, all of which will doubtless occupy much of the time of visitors in their inspection, but which are only distantly related to the art of engineering.

In area covered, in boldness of conception, in beauty of design and grandiose aspect of buildings, the Exposition of 1900 will far surpass its predecessor of 1889.

We cannot conclude without paying our tribute to the organizer and master mind of this great Exposition, to M. Alfred Maurice Picard, the Commissioner General. May the active energy of which he has given so many proofs extend to all of his collaborators, to the end that the coming Exposition may be formally opened at the appointed time, for there is not a moment to be lost if this much desired result is to be attained.

THE EVOLUTION AND FUTURE OF THE GAS ENGINE.

By Georg Lieckfeld.

WHEN comparison is made between the operation of the gas engine and that of the steam engine, one wonders how it happens that the invention of the steam engine preceded that of the gas engine by a whole century.

Gas explosions, with their very considerable development of force, were known long before the invention of steam engines, and one would suppose that these explosive phenomena would have been earlier studied and harnessed for work than the less obvious plan of artificially converting water into steam, especially as gas explosions occurred in the industrial occupations followed by the able men who did so much for the creation of the steam engine.

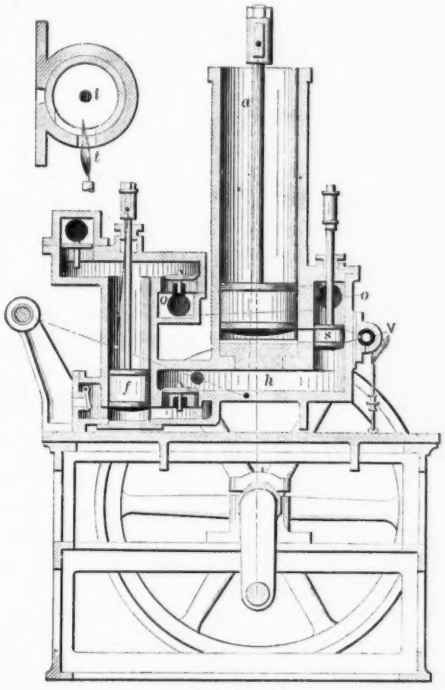
When lockmakers and smiths used bellows on their forges they well knew from experience that under certain conditions the bellows exploded with a loud report, for, if bellows are not used on a freshly covered fire, there thus being a deficiency of oxygen, the coal does not burn to CO_2 but to CO_1 and this gas having no other outlet, works back into the bellows through its nozzle, and becoming diffused through the air in the bellows forms an explosive mixture, which, when the bellows is started up again, is blown into the fire, ignites, flashes back into the body of the bellows, and either blows it to pieces, or with loud report finds outlet through the nozzle, scattering the burning coals.

In many other cases, as in blast furnaces, explosions have been observed, the gas being formed in a similar manner.

Notwithstanding the fact that gas explosions were observed centuries ago, no one understood how to utilize them. It was only after illuminating gas had been in use quite a long time that anyone began to think of mixing gas with air, to explode this mixture and use its power to drive an engine.

Patent records have been called a manual of the history of inventions, and in such records we find that William Barnett, an Englishman, was probably the first (in a patent specification of 1838) plainly to claim the broad principles which still govern explosive gas engines. Barnett describes three different engines, one of which is here illus-

trated. In the drawing *a* is the working cylinder, *c* the air pump and behind this lies the gas pump, not visible in the illustration. These two compression pumps force air and gas into the loading chamber *h*. When the working piston is on the lower dead center the piston valve *s* opens and connects load chamber and working cylinder and also opens the ignition inlet *v*, the claim being that the flame *t* ignites the charge.



BARNETT'S GAS ENGINE.

After the piston has been driven by explosion to the upper dead center, the slide valve *s* goes down, opens connections between *o* and the upper side of the air pump *c*, which is also descending, and thus the products of combustion are drawn from the working cylinder, and, on the up stroke of the air pump piston, expelled from the engine. Barnett finally claimed that it was not necessary to draw out the burnt gases, but that they can escape into the open air through a valve.

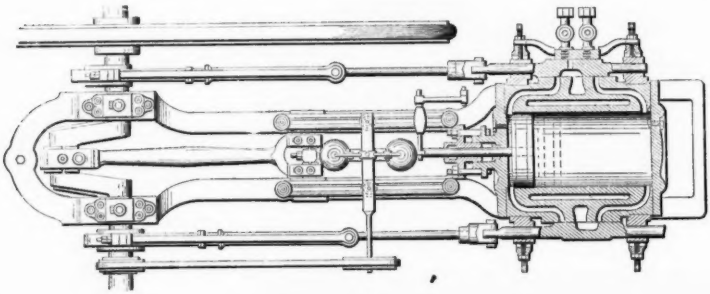
In describing variations of his engine, Barnett also claimed ignition by means of platinum sponge, which glows the more readily because of the compression of the gas mixture.

From the great number of variations described, both for engines and ignition apparatus, it is evident that Barnett was well aware of the value of his invention, and was attempting in his patent specifications to cover all possible forms. Although the gas engine designers of the present time can see plainly that Barnett's design would not have produced a practical working engine, nevertheless it must be emphasized that Barnett's ideas include all that is fundamental in the theory of the modern gas engine:

1. Compression of the gas mixture before ignition.
2. Combustion in the working cylinder.
3. The dilution of the gas mixture with combustion products remaining in the load chamber.
4. Ignition on a dead center.

After this first effort to design an operative gas engine, there was a long period of inactivity. The clearly expressed fundamental ideas of Barnett's specifications were forgotten, and not until 1860 was the first gas engine made; one which actually worked and which to some extent was practically used; namely, that of the Frenchman Lenoir. Although the principles used by Lenoir for his engine had not the fundamental value of those of Barnett, nevertheless to Lenoir must be conceded the great merit of being the first to whose patience and energy we owe a practical solution of the problem of the gas engine. He may, therefore, rightly be considered as the inventor of the gas engine, for, it is an immeasurably greater merit to carry into execution a creative thought than merely to apprehend it.

As shown in the illustration, the Lenoir engine in outward form



LENOIR GAS ENGINE.

and method of utilizing expansive power, closely resembles the steam engine. On the part of the outstroke, the piston draws in the gas mixture until the dotted position is reached, when the gas is ignited by an electric spark, and the piston is then driven the short remainder of the stroke by the force of the explosion. On the return stroke the same operation is repeated. The Lenoir gas motor was therefore a double acting engine without compression.

Lenoir made many attempts to improve his engine, especially to reduce the great consumption of gas. For instance he used as dilute a gas as possible, but in order to be sure of ignition, a richer gas was injected at the last moment, near the spark. He also attempted to use a jet of steam, hoping through it to prevent the very rapid fall in pressure after explosion.

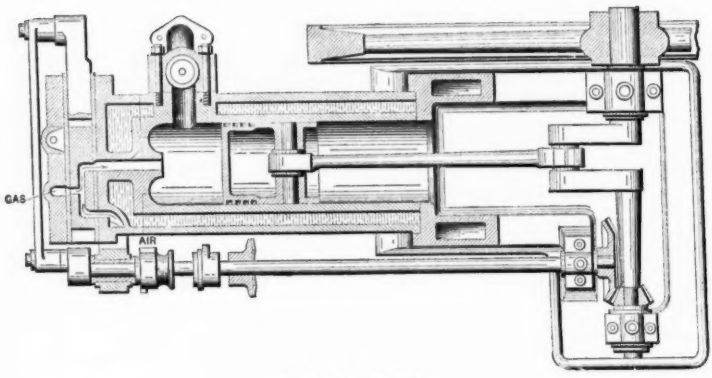
Twenty-six years ago the writer had the privilege of watching a Lenoir gas engine at work driving a spinning machine, and although it was on the second story of a dwelling, it worked in absolute silence. The operating costs of the engine were, however, very heavy, the consumption of gas being three cubic meters, or about 106 cubic feet, per horse power hour, or six to eight times the requirement of the best modern gas engines, even larger relative quantities of lubricating oil being also used.

Almost immediately after the appearance of the Lenoir engine, Gustave Schmidt published in the year 1861 in the *Zeitschrift des Vereines deutscher Ingenieure* a study of its theory, and he showed how its efficiency might be very greatly increased by compressing air and gas before combustion in the engine. Although Barnett had designed his gas engine in 1838 for a compressed gas mixture, this fundamental principle was but very slowly introduced in practice.

Hugon made an attempt to increase the efficiency of a Lenoir engine by a spray of water at the instant of explosion, hoping to utilize in the making of steam a part of the heat so suddenly and wastefully set free, and thus secure a more uniform pressure than that to be obtained from the very hot gas combustion.

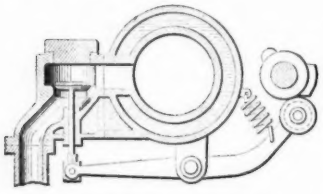
The next step was the atmospheric gas engine by Otto and Langen of Deutz, near Cologne, Prussia, in which advantage was taken of the rapid evolution of heat at the moment of explosion to drive an easily movable "flying piston" and indirectly to utilize the vacuum under the piston to draw it down again while doing work.

Full fifteen years went by before the value of compression was remembered and it was N. A. Otto, of the above firm of Otto and Langen, who *built* the first compression gas engine. It is well known that



OTTO GAS ENGINE.

Otto used the two stroke cylinder in his first compression gas engines. He added to the working-cylinder a mixing-pump which drew in the air and gas mixture, *compressed* it and forced it over into the working cylinder. This style of motor was not a practical success, and it is to Otto's credit that he was the first to introduce the *four stroke* principle in gas engines. The first stroke draws in the gas mixture, the second compresses it, explosion follows and work is done during the third, and the fourth stroke drives out the burnt gases. This principle is the governing one in the plan and construction of all gas engines on the market to-day.



SECTION OF OTTO CYLINDER.

The engravings show an Otto four stroke compression gas engine. The working cylinder is closed at one end only, and this closed end extends beyond the stroke and serves as a reservoir chamber for the compressed charge. The piston draws in, on its forward stroke, the mixture of gas and air, the inlets being marked by the arrows. On the return stroke this mixture is compressed. During both of these strokes the engine is doing work as a pump. Just before the end of the compression stroke, before the piston has quite reached the dead center, the slide valve at the back of the load chamber is opened and permitting ignition; explosion follows, and the piston is driven forwards with great force. At the end of the stroke the exhaust valve

is opened and permits the escape of the burnt gases into the open air, and the piston moves into its first position, thus forcing out the remnant of the burnt gas, except what remains in the clearance chamber.

The clearance chamber is filled with burnt gas, which fact must not be overlooked. The fresh charge is mixed with these products of combustion which consists mainly of steam and carbon dioxide. It is only in the inlet passage between load chamber and valve that there is no adulteration of the charge, and during the whole suction stroke this inlet is filled with pure gas mixture, while the chamber is charged with adulterated and diluted gas, difficult to ignite and slow to burn. This design adds to the reliability of ignition, and we must also give it credit for its silent, even running, absolutely free from jerks or blows, and very great gas economy. In the Otto patents the greatest importance was claimed for the inlet passage, connecting the ignition chamber with load chamber. It was named the shot inlet, because the pure explosive mixture contained in it was counted on to burst forth like the flame from a gun into the combustion chamber, a reliable and complete combustion of the whole load resulting. These Otto patents, among other things, prevented others from using, without infringement, a cylinder lengthened beyond the piston stroke, with a communicating inlet between ignition and load chamber. Many suits have been instituted in all civilized countries to protect these patents upon which a monopoly of gas engine building virtually depended.

In Germany these patent suits dragged their weary length from 1878 to 1892.

To-day it is generally acknowledged that the shot inlet and also other claims of the Otto patent are not as important as was imagined. The ignition point is no longer placed in the inlet passage, but directly in the load chamber, the necessity of having an ignitable gas mixture there naturally following. The sudden burst of flame of the Otto arrangement from the inlet into the load chamber is omitted, yet good combustion is secured.

One would imagine that the extraordinary improvement effected by the use of compression in gas engines, would have led to further progress along the road first followed with such success by Otto, but this was not immediately the case. Ten more years passed before anyone dared to use higher compression than the 3 to 3½ times, which Otto employed.

About 1887 the brothers Korting of Hanover built gas engines which worked with compression of 4 to 5 atmospheres, and the favorable economy in gas secured by this increase made everybody realize

its extreme value, and forthwith engines were everywhere built with high compression.

Among others, the engine designed by Banki, and built by Ganz & Co., of Budapest used compression to 6 and 7 atmospheres and the gas engine "Charon" built by La Société Nouvelle des Moteurs á Gaz of Paris, uses 7½ atmospheres. To-day gas engine builders do not hesitate to use 10 to 12 atmospheres. With this increase in compression there has been a simultaneous increase in the rate of revolution of the fly wheel and an increase in the area of valves.

To these developments belong the main credit for the increased efficiency of fuel consumption in gas engines.

Another element which has stimulated gas engine building is the invention and perfection of apparatus for the making of producer and other gases, introduced by Emerson Dowson, an Englishman, about 1885. With the help of these very simple, cheap and easily operated producers which render 80 per cent. of the heat units in the fuel used, gas engines have passed beyond the stage of small engines and may be said to have begun to compete with steam engines of the largest size; not only because they are independent of central gas supply, but also because they utilize to higher degree the energy in the fuel, and can be run with a minimum of labor.

Up to the present time, whenever power is to be obtained from a heat engine, the piston engine has proved itself the best and most efficient.

In order that the heated gases may be used to the fullest extent possible, their expansive power should be expended at the end of the piston stroke, and as much as possible of the stored heat contained in them converted into work and as little as possible of the heat be lost by radiation.

With the steam engine an efficiency of 13 per cent. to 15 per cent. of the theoretical heat units in the combustible may be realized. A gas engine of best construction converts 30 per cent. of the theoretical heat of the illuminating gas used into work. It must however in this comparison not be forgotten that the fuel used in a gas engine is refined or purified, while in the steam engine furnace the raw material is pitched in as it comes from the mines. Since however the Dowson producer converts over 80 per cent. of the theoretical heat in the raw fuel into a gaseous form, which can then be used in a gas engine, we have still for the gas engine a practical efficiency of 24 per cent. But we must again remember that this high efficiency of the gas engine occurs only under full load, and that the yield in work from the

combustible falls off in a very marked degree under partial load. This serious drawback to the gas engine can be explained by the following considerations.

As already mentioned, the economic employment of a piston demands that with the end of the stroke the expansion of the hot gas shall have reached its limit. This condition can only be satisfied by a gas mixture of certain proportions used as the charge, which can be calculated from the volume of the cylinder, the gas to be injected into it, the volume and nature of the burnt gas products in the charge chamber. Only in certain definite proportions of air and gas is the mixture most efficiently burned. Any change of proportion, whether gas is increased or diminished, or whether the residue of burnt gas is changed in quantity, immediately causes much less effective combustion. In the usual type of gas engine it is not possible to lessen pro rata both gas mixture and residual burnt gases. In every case, if less gas mixture is drawn into the engine, a charge results which not only gives less initial pressure, but also burns more slowly, giving higher final pressures. In this inevitable slower combustion there is also inevitable dimnution of efficiency with anything less than full maximum load. Gas engines can therefore not be governed advantageously, as steam engines are, by cutting off the supply of gas (steam); but the builders, in order to save gas and yet lessen load, solve the problem by omitting explosions so that the engine is always driven with a full charge, and best combustion, even if these charges do not occur so frequently. That such governing is at the expense of uniformity and regularity needs no demonstration.

If regularity is absolutely essential, there must be a larger allowance of gas, and in that case the engine can be governed by diminution of load charge or by lessening the relative and essential proportion of gas, but in each case using more gas than the reduced load would seem to require.

As it has been discovered that the composition of the charge must remain unaltered, for highest efficiency in case of lighter load, economical and efficient governing is best secured by using a smaller number of charges. The smaller the size of the combustion chamber in an explosion engine, the smaller the quantity of residual burnt gases, and the less their diluting influence on the charge. As size of combustion chamber diminishes with increased compression, it follows, and this has also been verified in practice, that gas engines with very high compression show better economy under variable load than those of low compression, if both are regulated by variation in volume of charge.

From all this it follows that the gas engine is very far from satisfactory in its ability to proportion combustion to work done, and that this cause of deficiency is inherent in an explosive engine. To govern an explosive engine by gradual diminution of the charge, it would be necessary to diminish the residual burnt gases, and thus far this has not been accomplished in a sufficiently simple manner.

Attempts to use other modes of combustion than explosion, in heat engines, so as to control better the process of combustion are therefore quite justifiable, and have caused the invention of the so-called combustion engines as opposed to explosion engines.

In the explosion engines the combustible and the necessary air are stored *fully mixed in* the combustion chamber, ignition takes place on one plan or another from without, and combustion follows, according to the nature of the substance. In the combustion motors, combustible and air are introduced *separately* into the working cylinder and ignition takes place at the particular moment when the two substances meet. Air and combustible are not mixed in advance, but the rapidity of the combustion varies according to the proportions of each admitted. If larger quantities of both are used, more power is obtained than if lesser quantities are used in the same proportion. The gases, products of combustion, are wholly expelled and therefore do not affect the result.

It is plain that this kind of burning can be better controlled than explosion, for, in the latter case it is not possible to control in the same way the composition of the load.

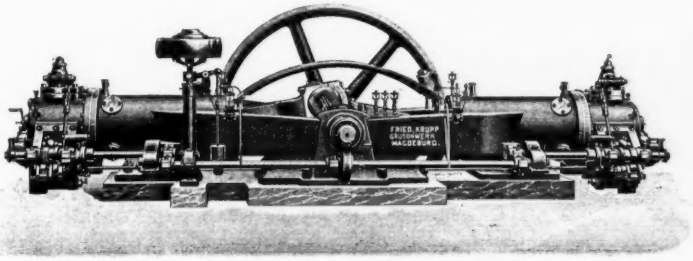
Combustion engines were invented almost as early as the explosive engines, and their development and design will form the subject of a subsequent paper.

The four stroke compression engine, as built by Otto in 1876, has shown itself a reliable, safe, durable engine which in the course of time has, in all its parts, been very greatly perfected. By increase of compression and more rapid revolution of the fly-wheel, by increased opening of the valves and suitable proportions to the combustion chamber a high degree of efficiency has been attained, the gas consumption having been very greatly reduced. Gas engines are now built in medium sizes using about 430 (12.7 cu. ft.) liters of illuuminating gas, equal to 2,150 calories (8,531 B.T.U.) per horse power hour.

That gas engines of large sizes and great power, equal to the largest steam engines can be built, and are in the future to be counted among the standard power engines, is already proved by many examples. In France there is a single cylinder gas engine at work

developing over 480 H.P. There are in Germany single cylinder gas engines of 170 H.P., which have been working steadily for a long time without trouble of any serious kind. The illustration shows a 300 H.P. gas engine built by Fr. Krupp. In England and the United States it is reported that even larger gas engines are at work. It is especially iron furnaces which can make enormous use of gas engines as they are in a position to supply all the fuel necessary by using the waste furnace-gases.

When there are as competent engineers for gas engines as there are for steam engines, the unfounded complaints about their unreliability will vanish and the conviction will become more general that gas engines are not only cheaper and more economical to operate than steam engines, but that they are also very much more convenient. Steam engines have been perhaps perfected to the utmost limit, but



KRUPP GAS ENGINE. 300 H. P.

this is not yet the case with the gas engines. Means will be found to build double acting four stroke gas engines which will be as reliable as the single acting engines now are. It has also been proven possible to increase compression in the explosion engines to an even greater extent than 12 atmospheres without risk of premature ignition.

It will also be possible to build internal combustion engines on the Brünter or Diesel models in perhaps improved form, and these, in economy of fuel and accuracy of governing may yet surpass the explosion engines.

Finally we may mention a peculiarity of gas engines which has never been satisfactorily explained, namely the fact that increase in size in the explosion type does not lessen fuel consumption to the extent that one would expect. The very best economy ever attained, 430 liters (12.7 cu. ft.) illuminating gas per h.p. hour, was in a 15 h.p. engine, the writer knowing of no instance surpassing it among

the larger engines. Some designers are of the opinion that internal friction increases out of proportion in the larger sizes, due probably to the difficulties of adequate lubrication of the long and heavy piston.

Others who use less compression in the larger sizes than in the small models ascribe the evil solely to this fact, and they have avoided the higher compression owing to the danger of premature ignition.

The writer's opinion is that in the combustion chamber of large dimensions, ignition is slower than in the smaller sizes, therefore more unfavorable. He suggests as an improvement a double ignition, one on each side of the cylinder, or even multiple ignition so that combustion may take place as efficiently as in the smaller engines.

A possible cause of unsatisfactory results is due to the fact that proper care is not taken to proportion the parts to the speed and volume of the gases passing through them.

In the endeavor to build noiseless engines and to avoid the hammering of the valves too little lift is given to the latter and they open and close too slowly.

The more the size of gas engines is increased the more important it becomes to have all parts in proper proportion. The great size of the cylinder, and the insufficiency of valve inlet prevent the rapid filling of the combustion chamber and its capacity is therefore not fully utilized.

EDITORIAL COMMENT

Each month the Engineering Index brings its indications of the current work of the scientific world as reflected in the papers contributed to the technical societies and in the engineerng press, showing not only the influence of passing events but also the lines along which future work may be expected. A new idea appears, sometimes merelv as a suggestion in a discussion, or in the form of a note to a learned body. In a few weeks some one else takes it up; then comes a popular article, and before long what was only an interesting fact becomes a commercial possibility, developing into a great industrial factor. An excellent example is found in the progress of the liquefaction of air. It is but a short time since a few drops, hardly more than a deposit of dew on the walls of a glass bulb, were exhibited in a lecture room as a rare curiosity; then came a beakerful on the table of a popular lecturer, followed by larger quantities, available for experimental purposes and original research, and now we have the announcement among the articles of the month of the completion of a commercial plant to supply thousands of gallons per day.

* * *

The story of liquid air is but a repetition of that of aluminum. Once a rarity in the chemical museum, then a commercial material at many dollars a pound, ranging almost with the precious metals, and all at once brought by the methods of practical electro-chemistry into the market as a commercial product with innumerable applications in the arts. There is something curious in the fact that the metal which applied electricity made possible in the markets is likely to become a rival of copper as an electrical conductor, and thus we find electricity supplying the materials for its own utilization.

In this connection it is interesting to notice the discussion in connection with the use of aluminum for military utensils, based on the experience of the French troops in Madagascar. The matter is reviewed at length elsewhere, but the necessitv of using the purest metal possible for such purposes is undoubtedly demonstrated.

* * *

The question of internal waterways in Germany, already alluded to before in these columns, forms an important feature in some of the continental papers of the month, largely because of the political character which has become attached to the Rhine-Elbe Canal project. That the canal will ultimately be constructed in some form is more than probable, although the present indications are that a strong oposition to the plans of the government has succeeded in delaying the matter for the present. From an engineering standpoint the plans as urged by the government seem both feasible and desirable, but political and engineering considerations do not always harmonize, either in English or German speaking countries.

Another question which is attracting interest on the continent, and in which both engineering and politics are involved, is that of the government control of water-power rights. In Austria, Italy, and even Switzerland, the activity in the development in water-power, consequent on a realisation of the possibilities of electrical transmission, has caused the government authorities to see that there is opportunity for an increase in national power, and possibly in national revenue; but the methods of handling such a delicate problem cause the engineer to prefer to leave this subject to those accustomed to more diplomatic methods than those in which he has been trained.

* * *

Meanwhile the development and application of natural sources of power goes merrily on, and from all parts of the world come accounts of plans for new hydraulic and electric power plants.

Where water-power is not available the later idea of the utilisation of waste gases in gas motors continues to find favor, and

in this connection the latest plan is to utilise in like manner the far richer gases which are now being discharged and wasted from many coke ovens on both sides of the Atlantic. Even where by-product coke ovens are used the gases possess a high calorific value after the volatile products have been removed, and indeed in every kind of furnace it appears that there is much valuable fuel now being wasted in the form of gas which might be recovered to advantage. The whole subject of gas engineering continues to attract much attention, judging from the number of papers appearing in the journals of the month upon this and allied subjects. So far from having been injured by the competition which electricity has produced, there is no doubt that it has been immensely stimulated, and if it were possible to go back to that state of darkness which people once thought was light, before the days when gas was prodded by electricity into something like real activity, great would be the wonderment as to how such a state of affairs could possibly have been endured.

* * *

The manner in which various engineering matters are inter-related is well shown in the question of municipal water supply. Two questions are presenting themselves simultaneously before the engineers of many great cities—one, the demand for purer and better water supply, the other, a growing disposition on the part of the users to waste the water in a most reckless and unnecessary manner.

Although these are apparently independent questions, yet it is found in nearly every case that the only method of obtaining a pure supply is to introduce filtration, and that the only way to make filtration possible is to limit the supply within reasonable bounds in order that the cost may not be prohibitory. Several papers this month relate to both branches of this important subject, and the end is not yet, as many facts clearly indicate.

Closely allied to this is the ever present matter of sewage disposal, this time in a special phase of its many sided nature. In nearly every city there is much trouble over the disposal of the wastes from manufacturing establishments, and, being large taxpayers, such establishments demand the rights of the city sewers for outlets. So long as the wastes are not injurious to the sewers or public health this is all right, but it is found that much dangerous matter may be thus delivered, and that in many cases the temperature of the discharges is so high as to cause rapid decomposition of the organic contents of the sewers, to say nothing of the damage done to the sewers themselves by reason of the sudden changes of temperature. Clearly it is within reason to require that injurious wastes should be rendered innocuous, and that hot liquids should be cooled below a safe maximum temperature before delivery into the sewer system which serves an entire city.

* * *

In the realm of electricity space telegraphy continues to be the object of interest. The first stage of wonder and surprise having been succeeded by the usual one of "I told you so," is now being followed by the general attack all along the line to produce improvements which shall make every detail altogether practical and successful in daily work. It is the story of the telephone over again, and there is little doubt that before long this nine days' wonder will have become a matter of such every-day service as to be quite superseded in the popular eye by the next novelty. The Wehnelt interrupter has not yet passed the earlier stage of lecture room and laboratory experiment, probably because of the fact that it possesses less immediate practical utility; but many papers show the active interest which it still excites, and practical results will doubtless soon follow.

It has indeed been a busy month for the engineer, and he has done good work therein—work which not only makes a good showing for the present but is full of promise for the future.

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Two points are practically noticeable in the manifold comment called out by the recent successec of American firms in getting contracts for engineering work in Great Britain and the colonies. The first—curious rather than practical—is the eagerness of the "man of one idea" to make every fact uphold his philosophy. Thus, one reformer finds the solution of the whole

matter in the American patent system—but his argument is weakened by his entire mistake as to what that system is; another, with a deplorably low opinion of the British workman, sees the British industrial structure tottering to its ruin, undermined by the flood of strong drink; a third attributes the inroads of American industry to the better education of the American mechanic, and to borrow a phrase from the children's game, he is "growing warmer." Social and economic conditions lie closer to the root of the matter than is usually admitted by engineers. But it is a tribute to the general breadth of economic view in Britain that hardly anyone—except an occasional maker of a rejected tender—has suggested the artificial "protection" of shutting out the foreign competitor.

And this brings us to the second point, immensely practical and significant; that is, the alert and widespread attention centered upon even the smallest inroad of the outside competitor into the "sphere of influence" of the English engineering trades—the determination to sift the causes to the last grain, and the frank readiness to face the conclusion, honestly and without disguise, and to grapple boldly with the situation, whatever it may be, and, drowning the pipings of the little philosophers, there is rising the deep, steady, consonant chorus of the true prophets proclaiming the real cause. It is well voiced by the writer of a clever review column in a London daily. Commenting upon the current articles in THE ENGINEERING MAGAZINE by Mr. Orcutt—a prophet in the fullest sense, since he wrote before the event—the reviewer says:

"But we believe that the true and correct reply is that of Mr. Orcutt in THE ENGINEERING MAGAZINE. He ascribes the British defeat to two great causes; the intense conservatism of mind which marks the British manufacturer and the want of originality in the British working-man.

"The British manufacturer will not adopt the latest and best machinery. He buys a particular type of machine because he and his fathers before him have always bought it. He does not ask if other machines are better suited to his work. He is conservative, and the British maker of machines, whose energy is not being constantly stimulated, also grows conservative. The consequences we see in such a fact as the erection of a huge gun-lathe, made, not in England, but in America, by the go-ahead Vickers works in Sheffield. Time was when England built gun-lathes for the world. And now we cannot make them for ourselves!"

But there is in this no note of pessimism. England has been adapting herself to her environment for a thousand years. We may conclude, with the reviewer that: "the nation which governs India and which has regenerated Egypt need have no fears if it will only gird up its loins and realise the facts with which it is face to face. But sleep no more in slothful overtrust is our entreaty, addressed both to our manufacturers and to our working-men."

* * *

Mr. Barnes, Secretary of the Amalgamated Society of Engineers, has issued a circular devoted, in part, to showing that some of the much-discussed American orders—especially those for locomotives, were, after all, relatively inconsiderable. Citing Board of Trade returns, he shows that British exports of locomotives, and of all engineering products, are increasing annually at a very handsome rate and that the corresponding figures from American official statistics look small in comparison.

We may grant all this, and more. We may admit, as everyone must, that British engineering firms, almost without exception, have orders booked for months—sometimes for years—ahead; that many of them, far from seeking more business, are almost seeking escape from the press of work crowding upon them; that consulting engineers (to quote a distinguished correspondent) are regretting "that the day has only 24 hours and not 36." We may admit all this, and still miss the point.

The question is, not "are British engineering works taxed by the present volume of work," but "are British engineering works employed to the full of their possible capacity?" If they are, then surely it is time to build greater; if *not* (and this, we believe, must be the honest answer) if arrangement, or re-equipment, or re-organisation will increase their output—then the

change necessary for greater capacity must be made, or the main current of orders will break away from the old channel and follow the course of the present overflow. Mr. J. Slater Lewis has now in preparation for THE ENGINEERING MAGAZINE a series of papers upon "Works Organisations for the Maximum of Production" which will be most valuable at this juncture.

For the American contracts have been characterised not only by the quicker delivery promised, suggesting greater immediate capacity in the works securing them, but by far lower prices, indicating still larger differences in manufacturing economy. Some of these differences, as they appear in locomotive building, are pointed out by Mr. Rous-Marten in this number. An extension of similar principles of "standardisation", to even larger engineering construction will be discussed in future issues by one of the foremost British engineers.

Granting everything ever claimed for American steel-making, it could account for a fraction only of the difference; it is in labour-costs and in constructive practice that the American competitor wins over his British rival. Unless he can be met on these grounds, sentiment will not long dominate home orders, and the decline of demand for British engineering products in export markets will be still speedier.

REVIEW OF THE BRITISH PRESS

Wind Pressure on Buildings.

THERE has been more or less discussion of late as to the proper allowance to be made for the force of the wind in proportioning buildings and other structures, and although there have been numerous cases of overturning and wrecking from the force of the wind it has been strongly maintained that the usual allowance is more than sufficient. Probably no structures offer a better mark for the wind than do gas holders, and the great bulk of such structures, together with the impossibility of securing them firmly to foundations, renders the estimate of wind-pressure a matter of especial importance to engineers engaged in connection with such work. A very full and valuable discussion of this subject was contributed by Mr. J. O. V. Irminger at the recent meeting of the Institution of Gas Engineers and his treatment was so full and broad as to be of interest to structural engineers in all lines of work.

After referring to the experimental investigations of Professors Langley, in America, and Kernot, in Australia, as well as of Herr Vogt, of Copenhagen, Mr. Irminger describes some very interesting experiments of his own, in which models of various forms were exposed to the draught produced by a chimney 100 feet high, careful measurements being made of the pressures and suctions on all sides. The results of these tests are tabulated in connection with the computed values, using the formulas of previous experimenters, and fairly consistent figures are obtained.

The influence of the sucking action of the wind is especially important, acting as it does to modify very materially the direction of the resultant for which provision must be made in the construction, and the lifting effect upon roofs and gasholders should always be taken into account.

Referring to the statement of Sir J. Wolfe Barry concerning the excessive magnitude of the Board of Trade allowance of 56 pounds per square foot for wind-pressure, in connection with the Tower bridge, Mr. Irminger shows that this suction effect has much to do with the diminishing of the direct pressure of the wind, and cites an instance of the measured pressure on a large gasholder in a storm as being only 4.9 pounds per square foot.

That such measurements should not lead engineers to err on the side of too small allowances for wind pressures, Mr. Irminger gives an abstract of the computations of Mr. J. Baier, upon the wind pressures which must have existed during the storm at St. Louis, U. S. A., in the summer of 1896. The damage done by that great storm is well known, and by computing the strength of some of the structures which were overthrown the actual force of the wind was determined. Mr. Irminger states that the velocity of the wind on that occasion was about double that known in Europe, and hence of four times the force, ranging from 40 to 60 pounds per square foot.

"Such a hurricane simply rases all and everything in its path but is fortunately not known in Europe; and, if we assume the forces mentioned by Mr. Baier are correct, it cannot be wondered at that the forces estimated in Europe are considerably less violent."

Mr. Baier's conclusions agree with those deduced from Mr. Irminger's experiments, and show that the wind acts in a direction quite different from that generally assumed and usually provided for in designing bridges, roofs, and buildings. "One may thus assume that the experiments on the small models have been verified by nature itself, and that calculations of the wind's force must be made on a different basis than hitherto, inasmuch as, besides the horizontal effects, the upward force must be taken into consideration, the power of which can equal half the wind's normal pressure."

The discussion of the paper bore out the idea that until now wind pressures have been studied with rather preconceived ideas. The construction of buildings has

proceeded in accordance with these ideas, and except when great catastrophes have called the attention of engineers to the failure of structures, very little seems to have been done in the way of investigation to see whether the established ideas are correct or not.

The increasing size and altitude of framed structures is rendering the question of proper allowance for wind-pressure a most important matter, and the experiments made by Mr. Irminger, as well as those of others cited by him, form valuable contributions to the subject. When such buildings are being designed it appears desirable that small models be made and tested in the simple manner described, and there is little doubt that the stability of the structure during wind storms would be materially increased if such information is obtained and used in the preliminary stages of the design.

Petroleum Motor-Vehicles.

THE development of automobile vehicles has been retarded in England because of the onerous restrictions which were placed upon them until three years ago, but since then England has made rapid progress in all kinds of motor vehicles.

An excellent historical and descriptive review of the progress which has been made in one branch of motor-vehicle construction is given in a very full paper upon petroleum motor vehicles, read before the Society of Engineers by Mr. James D. Roots, himself conspicuously identified with the development of successful vehicles of this class, and therefore especially well qualified to speak on the subject.

Petroleum vehicles undoubtedly owe their practical existence to the persistent labours of Daimler, who indeed may also be considered the one who made petroleum motors for all purposes possible in a practical sense. Daimler's first vehicle patent was taken out in 1885, and was a very crude affair, being constructed like the old bone-shaker with a petroleum motor placed between the two wheels, with two small trailing rollers, one on each side, to prevent the bicycle from falling over when not in motion. The general arrangement, so far as the propelling machinery is concerned, was not unlike that of the Daimler motor of the present day, except that it had but a single cylinder. The petroleum was passed through a carburetter, and the tube igniter was used, and crude as the machine was, it contained the elements of practical success.

Daimler was followed by the patent of Benz, in Germany, and by Butler in England, and had been preceded in England by Hardaker, who patented in 1880 a motor vehicle operated by an internal combustion motor using gas compressed in a storage tank, but there is no evidence that this machine was ever built, and as it was designed to be used with compressed gas, it cannot be considered an anticipation of the modern petroleum engine.

Butler's tricycle was an ingeniously designed vehicle, but the defects in construction, which were probably unavoidable at that period, caused it to fail of practical success.

All these early vehicles used petroleum spirit, the vapour being used to form a carburetted air, which was exploded either by an electric spark or by a hot tube in the cylinder. Up to 1892 no attempts appear upon the record of the use of petroleum oil instead of spirit, but after that date the development in petroleum oil engines was sufficiently far advanced to permit of the application to vehicles, and Mr. Roots himself built a successful motor tricycle driven by a petroleum oil motor.

Notwithstanding the difficulties which attended the use of petroleum oil motors and ease of operation of engines using benzoline, the former rapidly displaced the latter for stationary use, the danger attending the storage and use of the volatile fuel being a very great objection to its use. The motor used by Mr. Roots was one of the "impulse every revolution" class, with a compression pump formed of the front stroke of the piston, the rod passing out through a stuffing box as in a steam engine. The motor was placed vertically between the rear wheels of a Coventry tricycle, and the motion transmitted to the axle by reducing bevel gears, a friction clutch being used to enable the tricycle to be stopped without stopping the motor; also for use when coasting. The principal objection to this machine was the tendency of the motor to reverse, because the new charge would sometimes ignite directly after it had entered the cylinder and

during the compression, and the vehicle would promptly begin running backwards. As this undesirable feature could not be corrected, this motor was replaced by one operating on the de Rochas cycle.

Later petroleum vehicles have improved, both as to motive power and mechanical construction, as experience upon the road has been gained, and the bulk of Mr. Roots' very complete paper is devoted to illustrated descriptions of the more successful and better-known petroleum vehicles of the present day. In many respects petroleum is preferable to electrical accumulators, especially for road vehicles, where it is almost a necessity that independence of local electrical power stations be secured. Petroleum may be procured almost anywhere, and with simple, inconspicuous, and effective motors, such as are now available, the petroleum engine is certainly well adapted for this trying service.

The general influence of the motor vehicle upon roads and transport is well emphasised by Mr. Roots.

"Consider what the position of road locomotion would have been if, as we may fairly assume, the same number of engineers had devoted their time, thought, and energy to the improvement of the road locomotive as in each generation since 1830 have employed themselves in the furtherance, improvement, and development of locomotion by rail. The high, and in some cases prohibitive freight charges upon certain railways, would now be impossible. The transport of all goods would have been cheaper, thus lessening the cost of country produce and market-garden stuffs and other goods to a great extent, especially in the large cities. Cheapness of transport will naturally cheapen the cost of all the necessaries of life; cheapness of transport by road would have cheapened freight by rail. Moreover, our roads would be better and wider, and would not be allowed to get into the bad condition we now find them in every autumn and winter, and it would be a finable offence on the part of any local authority to put down granite or stones on the roads without immediately rolling them in. It would be equally an offence to allow any road to get below a certain level of standard excellence. Travelling and inspecting surveyors would ere this have been appointed by the local governing board in each county, and if any roads should be found by an inspector to be below a predetermined standard of excellence, the local authority in whose district they were should be summoned to answer the charge before the Quarter Sessions. Permitting a bad road should be made a punishable offence, and it will be made so in time.

English and American Bridge Design.

THE publication of the detailed plans of the Atbara bridge calls forth in an editorial in *The Engineer* some plain language concerning the different methods in vogue in such work in England and in the United States, and in view of the marked interest which this work has attracted the subject will bear emphasising here.

The important question in connection with the bridge was that of prompt erection without false works, and as all the tenders from English builders were of the riveted lattice type, for the erection of which false works are necessary, the contract went to America. The designs show that the accepted bridge is of the American pin girder type, which can be erected by travelling derricks carried first on a span erected on the shore, and then on the successive spans as completed over the river, no false works being required.

Commenting on this straightforward solution of the problem, *The Engineer* asks:

"Even at the risk of being considered ungracious or troublesome we cannot resist asking the question: Why a pin bridge was not suggested in the first instance to English builders? They could have carried out the work just as well as any American builder.

"There is no doubt that this is entirely true, although pin girder bridges do not generally find favor with English builders. In general bridges are designed in England by civil engineers, who are not in close touch with the bridge builders, with the result that there is material loss, both in time and in money, which might have been avoided.

"So far as the facts are known the Pencoyd Iron Works were given an absolutely free hand. There was the river, there were the piers, there was the open country for them. The spans and loads were stated,

that was all. We have not the least doubt that the result will be quite satisfactory, and we venture to suggest that, the ice having been broken, it would be well that the same system were adopted in this country.

"The present day is one of specialisation, and it is very easy to see that a firm whose whole time is spent in making and erecting bridges is far more likely to turn out work cheaply and expeditiously than a civil engineer who has a thousand-and-one other things to attend to besides designing bridges. The builder and steel maker will work into each other's hands, and the maker will take very good care to suit his design to ruling conditions. In fact, if the engineer does more than specify the loads per square inch of material and the general features of the bridge, he should go a great deal further and put himself in intimate relation with the steel maker and the bridge builder. The finished structure is the work of three different men, or sets of men, and unless they work together there must be waste of time, energy and money.

"It has been said that bridges are built by the mile in the States and cut off by the yard as required. This is not strictly true, but it is true that a great deal of work is done ready cut-and-dried in the offices of the best firms, and that they are always in a position to submit designs for any bridge, carefully prepared to reduce the expenditure of time and money to a minimum. The case of the Atbara bridge will go far to drive home the knowledge of this fact. We trust that the lesson conveyed will do much to place the relations of the civil engineer, the steel maker and the bridge builder on a better footing than they have recently occupied."

Comparisons of Similar Structures.

It is often a matter of great convenience and importance to be able to construct experimental models on a reduced scale and determine matters of proportion by trial, but it is most necessary to know in such cases the true relation which the completed structure and the model bear to each other. A very thoughtful and valuable essay upon this subject was presented before the Institution of Engineers and Shipbuilders in Scotland, by Professor Archibald Barr, and published in the *Transactions*, and while only a brief abstract of this important paper can be given here, some of the salient points can be mentioned.

No apology is offered for the fact that tests upon experimental models are often necessary, since, from the very nature of the case many mechanical problems must be indeterminate, and especially in designs which are wide departures from accepted forms it becomes almost a necessity to verify theoretical deductions by experiments such as are discussed by Professor Barr.

After showing the difference which exists in relative strength between large and small specimens of like materials, Professor Barr discusses to relations of similar figures and gives the laws, as enunciated by Professor James Thomson many years ago, showing the relations which exist between loads and stress in similar structures of various dimensions. This includes the very important subject of the shape of test pieces for structural materials, and the necessity of having test pieces of similar form is emphasised.

Some very interesting comparisons are made between animals of various sizes, and the case of the spider and the elephant is illustrated to show that a greatly increased quantity of material is required for a given increase in size if a corresponding strength is to be attained.

If the elephant were constructed on the proportions of the spider he would have crooked legs 80 to 90 feet long and about 6 inches in diameter. Various other examples from nature are given, all of which help to show the principles very clearly.

When structures are increased in size the relative importance of various conditions is altered. In railway bridges we have to consider the weight of the structure itself and also the weight of the heaviest load that may come upon the rails. When the structure is small its own weight is unimportant compared with the load which it is to carry, but with increase of span the weight of the structure becomes more and more important. In the case of suspension and cantilever bridges the greatest weight of structure per foot of

span occurs at the piers, where it produces least effect, whereas in simple girder bridges the weight is mostly concentrated at the centre of the span, where it produces the greatest effect. But even with this very favourable element in the design the Forth bridge had to be designed almost entirely to bear its own weight and the wind pressure. Had the bridge been designed as a monument or as an ornament, and not to carry any railway tracks, it would—assuming the same general outlines—have had to be almost as strong as it is for the same general security.

The question of the stability of structures must also be considered when using different sizes in comparison. Here the stability of the larger structure is greater in proportion than that of the smaller one, one obelisk of double the dimensions of another having also double the stability, and the case of the inferior stabilty of model yachts is given as an excellent example of the diminished stability of small structures.

A number of interesting diagrams are given to illustrate the points made in the discussion, and the rules are enunciated in such a clear and intelligible form as to make the paper one of the utmost value in a department of mechanics which has been too little studied heretofore.

Blast Furnace and Coke Oven Gases.

In considering the utilisable heat and power which exists in the waste gases of blast furnaces, the much richer discharge gases from the coke ovens have hitherto been overlooked as possible sources of energy. This subject was brought out in a paper by Mr. Enrique Disdier, of Bilbao, at the recent meeting of the Iron and Steel Institute, and his views attracted material attention.

Every blast furnace uses coke as fuel, a ton of coke being required for every ton of iron produced. By placing the coke ovens in close proximity to the furnace it would be practicable to use the lean gas from the blast furnace to heat the coke ovens, and use the rich gas from the ovens for motive power. Since the gas from a coke oven possesses almost as high a calorific value as illuminating gas, the advantage of this method is evident, and all other things being equal the plan would certainly be most efficient.

Taking comparative figures, a furnace producing 100 tons of pig iron daily should be able to provide 2,100 horse power if the waste gases were used directly in gas engines, but only about 600 horse power if the same gas were burned under boilers. The gases from coke ovens of a capacity of 100 tons per day are estimated to be capable of producing 547 horse power when used in gas engines, about 60 per cent. of the heat from the gases being required to heat the ovens.

If, however, the coke ovens were heated by the furnace gases, and the whole of the oven gases were used for driving the engines the increase in power over that obtained by burning the furnace gases under steam boilers would be 2,400 horse power, the value of coal saved being more than £12,000 per annum.

Mr. Disdier says:

"Far-reaching changes in blast furnace practice may be expected when coke ovens and blast furnaces are placed side by side, forming one complete plant, and working according to the method described above. Steam boilers, steam pipes, steam engines and gas producers will be dispensed with, and will be replaced by a gas main, through which coke oven gases will be distributed to furnaces and gas engines. A central station, with dynamos driven by gas engines, might also distribute electricity to electric motors scattered about the works to replace steam engines. Excellent gas engines, rated up to 250 horse power, and capable of being worked with coke-oven gas without modification of the ordinary form, have already been built, and their general adoption is only a matter of time."

While the plan for using blast furnace and coke-oven gases in conjunction, or rather, successively, in the manner indicated in Mr. Disdier's paper, possesses some advantages, it is doubtful whether it is sufficiently superior to the direct use of the blast furnace gases in the engines to be worth the additional complication involved. In another column the interest which appears in this matter in Germany is shown, and there appears to be little doubt that before long the united interests of furnace

managers and gas engine builders will bring forth some very practical results. The difficulties which have thus far been encountered are by no means insuperable, and there is every reason to believe that before many years have passed the escaping gases from blast furnaces and coke ovens will all be fully utilised and no longer regarded as wastes.

Mechanical Engineering and Ship Building.

In his presidential address before the Institution of Mechanical Engineers, Sir William H. White, among other interesting points drew a strong picture of the close relation which modern shipbuilding bears to mechanical engineering, showing how entirely the modern vessel, whether for war or for merchant service, is the product of mechanical operations and mechanical skill. Says he: "Mechanical engineering has intimate relations with all other branches of engineering. With none has it been more closely associated than with shipbuilding in recent times, and upon none has its influence been greater or more beneficial. The growth of our shipbuilding industry and the marvellous development of our mercantile marine during the last forty years are matters of common knowledge. The causes which have contributed to this supremacy are not so well understood and the part which mechanical engineering has played is not generally appreciated."

After enumerating the statistics of the growth of British shipping during the period indicated, and dwelling upon the changes wrought by the substitution of iron for wood and steel for iron, Sir William shows the contrast between an old-time ship-yard and one fitted out with modern mechanical appliances.

"The contrast between former conditions and those now to be seen in a modern shipyard is extreme. Machinery and labor-saving appliances abound and are essential and economical working. With ships of increased dimensions scantlings have become heavier, the sizes and weights of plates and bars have increased, special arrangements have to be made for transporting and handling materials, and the power of all classes of machinery has had to be increased proportionally. In a well-equipped yard the most careful consideration is given to every step necessary in dealing with materials, from their delivery up to the time when they find their places in the structures of ships. The stacks of plates and bars are so situated that the materials can readily be lifted from the trucks on arrival, or out of the depot when required for use."

The general use of traveling cranes and gantries is a matter of note, and the increasing employment of hydraulic and pneumatic tools, both for stationary and portable service, is also important. It is in the combination of all the multitudinous variety of machines and tools that the great influence of the mechanical engineer upon modern shipbuilding is seen, and it is not only the work of the mechanical engineer but also that of the electrician which has been utilised to the utmost.

"Electric power is being extensively used in some of the best equipped shipyards, apparently with satisfactory results. It is probable that the system will be much more extensively employed before long. For large machines with separate motors, and for groups of smaller machines, electric driving has much to recommend it. For operations that have to be performed *in situ*, portable electric machines are found most useful. In some cases, especially in elaborately fitted warships, it is found advantageous to establish on board temporary machine shops, which can be most conveniently driven by electric power."

When it comes to the preparation of the material used by the shipbuilder, the influence of the mechanical engineer predominates still more. Modern shipbuilding could not exist without the great progress which has been made in the manufacture of structural material.

"The shipbuilder is under great obligations to the steel maker for this progress in manufacture; but the mechanical engineer has had a hand in its achievement by designing and making the plant used in the steel works. In the device of new and more powerful machines for the shipyard his work has been more obvious. Without such machines the superior working qualities of steel could not have been utilised as is now done. Operations are now commonly performed on steel plates in a cold state

that were not possible with the best qualities of iron."

In fact all the long list of shipyard tools, including flanging, joggling, shearing and punching machines, as well as bending rolls, plate planers and all the better known machine tools are contributions of the mechanical engineer to the work of the shipbuilder.

On board the completed ship the work of the mechanical engineer is everywhere in evidence, from the propelling machinery, through the hoisting, lighting, ventilating and steering machinery, down to the smallest and pettiest applications of power. On warships especially is the work of the engineer conspicuous, so much so that the modern warship is not inappropriately called a "fighting machine."

Sir William White calls attention to the fact that the floating repair ship "Vulcan," of the United States Navy, was not the first of its kind, and that a "Vulcan," carrying a foundry, machine shop and forge shop, was equipped for the British Navy in 1887. Doubtless the floating machine shop will form an essential feature in modern navies of all nations hereafter.

British Coal Supplies.

THE probable duration of the coal supplies of Great Britain has formed the theme of many a discourse, and the latest and most important of these is the valuable paper of Mr. T. Forster Brown, read before the Society of Arts, and published in the journal of the society.

After noting the tremendous influence exercised by the increasing cost of coal upon the manufacturing interests of England, Mr. Brown calls attention to the main factors in the problem, which demand serious consideration. Briefly stated these are:

1. That while England has unworked coal resources capable of furnishing a supply for about 300 years, yet the best and cheapest of these will probably be exhausted in about fifty years, after which time the cost of working will rapidly increase.

2. That coal will be produced in the United States cheaply for a far longer period than England can, and that with the exhaustion of the cream of the English coal fields the question of the competition of American coal will become a matter of serious import.

3. That the large coal fields of Russia and China, when further developed, will also become serious additional factors in the competition of the future.

Mr. Brown then gives an abstract of Professor Hull's estimate of the approximate quantity of workable coal which will remain at the close of the present century at a depth of 4,000 feet, this being the probable utmost limit at which workings will be practicable. Taking into account the various fields, the result is as follows:

The Midlands	35,000,000,000	tons
The Great Northern	6,000,000,000	"
The Northwestern	11,000,000,000	"
The Western	2,000,000,000	"
The Welsh	20,000,000,000	"
The Scotch	8,000,000,000	"
The Irish	155,000,000	"

This gives a total of about 82,000,000,000 tons of coal for the total available resources at the beginning of the century.

"Taking all the circumstances into consideration the author of the paper estimates that of the best and cheapest of the coal supplies of Great Britain there originally existed about 20,000,000,000 tons, existing at a less depth than 2,000 feet below the surface, and that there may be probably remaining at the end of 1899 about 15,000,000,000 tons of this quantity, the bulk of which, he estimates, will be exhausted by the middle of the next century.

"This leaves about 67,000,000,000 tons of coal still available, sufficient to supply 250,000,000 tons a year output for upwards of 250 years, but comprising coal of either inferior quality or best coal obtainable at a greater cost per ton than at present prevails, owing to physical disadvantages by reason of depth and so forth."

After showing the causes for the increasing cost of working coal, including the increased cost of labor, the increasing burden of rates and taxes, and of large colliery staffs and improvements, as well as the various requirements of the Coal Mines Regulations and Workmen's Compensation Acts, Mr. Brown proceeds to show that no great increase in cost need be expected for the next fifty years, but that after that time a steady increase in cost will follow.

In view of this fact he suggests that what-

ever remedial measures are adopted they ought to be so arranged that they will come into partial operation by the end of a half century, and be capable of adjustment so far as they can be utilised from decade to decade to counteract the increasing cost of working.

In examining the coal resources of other countries Mr. Brown gives data about the coal fields of America, Russia and China, in particular, placing the American competition as the one first to be expected, and indeed already felt in distant British markets. The principal element to be considered in connection with American coal is the distance of the various fields from the coast, and the reductions which have been made in the cost of the carriage of coal therefore form an important element in this competition.

The Russian coal fields, while at least three times the extent of those of Great Britain, and worked at a less cost, are not likely to enter into competition soon, owing to the distance from seaports and the cost of transport; but the much greater coal fields of China are now on the point of being more extensively developed. Some of these fields are near the sea-board, and furnish coals of good quality for navigation and manufacturing purposes, and will doubtless enter into the problem before many years.

In all these foreign fields the tendency is toward cheapening the production of coal, while in Great Britain the reverse is the case.

The remedial measure suggested by the author is mainly in the direction of cheaper and better mineral transport, which, he thinks, would be obtained if the railways were in the hands of the State.

Under judicious State management he estimates that the income of the railways would be increased so that in thirty to forty years' time the increase in revenue would amount to £60,000,000 per annum.

This fund could then be used to lower the rates upon minerals in proportion to the increased cost of production. This method is to be supplemented by efforts to pay off the nation's indebtedness during the period when the cheapest and best coal resources yet remain, so that the reduction in rates thereafter may compensate for the increased cost of working. These and similar measures he believes to be worthy the serious consideration of politicians and the nation. If nothing is done the commercial supermacy of Great Britain will be seriously threatened, while if the capital value of the railways and other works were paid off in the fifty years, and the cost of travelling and the transit of minerals be reduced by one-half, the increased cost of coal, due to natural causes, would be practically neutralized, and the nation would be able to hold its own, so long, at all events, as the coal resources of the country endured.

REVIEW OF THE CONTINENTAL PRESS

Power Required by Machine Tools.

IN determining the power consumed by machine tools when operating under various conditions it is customary to measure the power required when running empty and deduct this quantity from that used when performing work. That this method is not exactly correct has long been known, since it is evident that the friction of the machine itself cannot be the same in the two cases, but it has been assumed that the error from this cause was not great enough to be of material consequence.

In the course of a recent series of experiments to investigate the power consumed by metal-working tools, MM. Huillier and Fremont made an interesting calibration of the dynamometer used, in connection with various determinate degrees of resistance at the machine, and thus were enabled to take the increased friction of the tool into account. A very full report of these valuable trials upon a number of tools is given in the *Bulletin de la Société d'Encouragement pour l'Industrie Nationale*, the whole forming an important contribution to this branch of technical knowledge. The variations in frictional resistance were made by delivering the power of the tool, a lathe for example, through a recording dynamometer of the Morin type, while various resistances were opposed by means of a Prony brake acting upon a pulley on a mandrel turned by the lathe. If the frictional resistance of the lathe had remained constant, the differences between the brake and dynamometer readings should have continued uniform, while any variations between the two measurements indicated the variation in the resistance of the lathe. By plotting the results of a number of such tests it was demonstrated that the friction of the machine increased directly with the resistance, being, in the case of a large lathe tested, equal to 16 per cent. of the added resistance on the brake. This coefficient of 16 per cent. varied somewhat according to conditions of lubrication, temperature, etc., and similar coefficients should be determined for different groups of machines before making extended tests.

In conducting their further trials upon the resistance of machine tools MM. Huillier and Fremont adopted the method of measuring by the dynamometer the amount of power delivered to the machine and taking the effective work from the pressure exerted at the cutting point of the tool. In order to measure the actual pressure at the tool an ingenious form of dog was devised, of which detailed illustrations are given in the original paper. In the usual method of working the dog is clamped firmly to the work to be revolved in the lathe, and is also engaged positively with the face-plate, the work being thus pushed around by the force applied to the plate. In these experiments, however, the dog is so arranged that it is pulled around instead of being pushed, and being connected to the work by a spring arm, the effort required to revolve the piece against the fixed resistance of the cut is measured by the deflection of the spring. An ingenious system of levers transmits the deflection of the spring, as it revolves, to a fixed recording card, and the leverage being known, the resistance of the tool at the cutting point is recorded continuously. When to this is added a simultaneous record of the speed of the surface upon which the cut is acting, all the data for the computation of the power exerted are determined. Another factor, which although not essential to the measurement of the power, is of interest in connection with machine design, is the direct pressure required behind the tool for a given depth of cut; this was determined by a special pressure device fixed upon the slide rest.

Before proceeding to the use of these devices they were carefully calibrated by the direct application of weights, and the proper factor determined, so that reliance might be placed upon the corrected readings, the deflections only being measured

and the corresponding pressures computed.

In the application of these devices some interesting observations were made. During a continuous cut, as in the turning of a shaft, for instance, the resistance was by no means uniform, varying in the case of a shaft 92 millimetres in diameter, from 270 to 337 kilogrammes. This variation may be attributed to two causes; the lack of homogenity in the metal and the breaking of the turnings. The unequal hardness of the material was evident, and it was easy to observe that variations in pressure on the tool occurred periodically as certain portions of the shaft came under the tool; the breaking of the turning could also be seen to affect the record of resistance. Making allowance for these variations by taking the mean resistance for a continuous run, and weighing the quantity of metal removed in the form of chips and turnings, a very complete record of the performance of various tools was obtained and tabulated.

In the paper above referred to the effort was made to determine more especially the power required by the various machines, and hence the conditions of the cutting tools themselves was maintained as nearly constant as possible, but in subsequent researches it is intended to vary the cutting angles, depth of cut, and similar conditions, and thus make practical comparisons. The present paper contains data from twenty-one different machine tools, giving for each machine the following data: speed of belt, pull on belt, power delivered, speed at the cutting point, weight of chips produced per hour, and net amount of work required to produce one kilogramme of chips, the tools including a variety of lathes, milling machines ,and drill presses.

The Calibration of Current Meters.

THE use of current meters of the "Woltmann Mill" type for measuring the flow of water in streams is very general, not only on the continent but in many parts of the world, and the reliability of such instruments is a matter of much importance, especially when the necessity of comparing observations made by various persons in many places is realized. The only way in which any general laws governing the flow of water can be deduced is by a critical anaylsis of a vast number of observations, and too often it has been realized that the conditions under which most desirable experiments have been made, render the results untrustworthy.

These facts give importance to the discussion as to the proper method of calibrating and testing current meters, and in a recent paper in the *Oesterr. Monatschrift fur den Oeffentlichen Baudienst*, Herr Ernst Lauda, engineer of the Austrian Hydrographic Bureau, gives a critical examination of the subject.

The usual method of calibrating such meters consists in passing them along a tank at a known rate of speed and comparing the readings with the actual speeds as measured. In most cases these trial tanks are similar, on a small scale, to those used for tests on models of vessels, the instrument to be tested being carried on a carriage supported upon rails on each side of the tank and propelled by electricity, the speed being recorded automatically.

The assumption has generally been made that a given speed of carriage corresponds practically to the same velocity of current in an open stream, and the equation obtained from a number of such tank trials is usually applied with confidence when the instrument is used on rivers and streams. Variations in the results which have been found to exist in the readings of such current meters have led to a doubt as to the influence of the proximity of the walls of the trial tank to the vanes of the meter, and it has been inferred that a more reliable calibration would be effected in an open body of water than in a comparatively narrow tank. The accuracy of measurement possible upon a tank, with its electrically propelled carriage and automatic recording apparatus, however, caused it to be thought advisable to investigate the actual effect of various widths of channel, and to determine, if possible, the true sources of the observed variations.

For this purpose Herr Lauda caused the Vienna testing tank to be fitted with adjustable walls of wood, which could be set to various distances apart, and, in conjunction with a movable wooden bottom, enabled a number of determinate widths and depths of channel to be obtained. Two current

meters, of standard reputation, were then given thorough investigation, both for channels of various dimensions, and for different rates of speed, and the results tabulated. By the method of least squares the corresponding corrective equation was then deduced in each case and the results expressed in curves, thus enabling the influence of channel section and velocity to be seen very clearly.

The first result of these trials was the demonstration of what had already been suspected, namely, that there were other sources of error besides the size of th channel. Thus the elasticity of the rod, which extended down into the water and carried the meter, caused a greater or less degree of flexure, and altered the angle which the revolving vanes presented to the direction of motion; and, in fact, the coincidence of the axis of revolution of the vanes with the direction of motion was rarely found to be exact, and any variation in this respect appeared in the reading of the instrument. This flexure of the rod is especially to be considered in making current measurements at various depths, the greater length of rod necessary for the deeper immersions being an important factor. Errors due to the imperfections of the testing apparatus, such as irregularities in the rails, and in the wheels of the carriage, as well as the unavoidable defects of the recording and measuring apparatus, all enter into the general result, and make it difficult to be sure of the location and magnitude of any error. These points in some instances appeared to overbalance any injurious influence which was directly due to the proximity of the sides of the channel, and in general the effect was found to be far less important than has hitherto been supposed. In the case of the meters tested it was found that with vanes from six to ten inches in diameter, changes in the width of the channel were without appreciable influence when the tank was more than about 30 inches wide.

The whole paper is an excellent example of careful investigation and valuable practical research, and shows how a popular impression, even among scientific men, may be found to be unsupported by actual and reliable experiment, while at the same time unsuspected errors are revealed.

Tests of Portland Cement.

THERE is always a mass of valuable information regarding the properties of materials of construction to be found in the publications of the Royal Testing Laboratory at Charlottenburg, and a recent issue of the *Mittheilungen* is entirely devoted to exhaustive researches into the properties of ten selected Portland cements, not only with regard to their resistance to rupture, but also in respect to their physical properties.

The tests which are recorded in the transactions were made conjointly by a committee of the professors at Charlottenburg and a commission representing the German manufacturers of Portland cement, the whole being under the general supervision of Professor Martens and the report being prepared by Professor Max Gary.

Before entering upon the detailed tests the preliminary portion of the report cites the general requirements which have been enunciated by the association of German cement manufacturers, and shows the value and importance to the consumer of the use of cement meeting those requirements. Apart from tests of strength these requirements include physical properties which have shown themselves to be of much importance. Thus if two briquettes are permitted to harden for 27 days, the one in cold water and the other in water maintained at a temperature of 90° C. (194° F.), and both appear hard as stone, free from cracks, and in the original form, the consumer may feel well assured that such a cement will be entirely satisfactory in practice so far as volume and solidity are concerned. If a more rapid test is required, a briquette which has remained for 24 hours in the air, and is then immersed for 2 hours in cold water and 24 hours in water heated to 90° C., should still be in its normal volume and condition.

To be classed as a slow-setting cement, a sample should remain for two hours after having been mixed to a mortar of normal consistency at the normal temperature, without showing any evidence of the beginning of any binding or setting. It is not always right to look with suspicion upon a slow-setting cement if it shows a marked rise in temperature during setting, for there are many excellent slow-setting cements in

which the binding process does not begin for six or seven hours after mixing, and in which, one hour after will show a rise in temperature of 5° to 7° C. Such cements are often better than those in which the setting begins in one-half to one hour, and is fully completed in seven hours, without showing any rise in temperature.

The quality of a Portland cement cannot justly be determined by a tension test made after 28 days' hardening in cold water, as a better idea of it can be obtained from a compression test, the best method being to make successive tests after hardening under cold water for 7, 14 and 28 days.

The full report includes information about ten standard German Portland cements, subjected to very careful detailed tests in accordance with the above general requirements, as well as many other modified tests, and extending over a period of more than three years, and the fully tabulated matter, together with the photographs of the test briquettes in various conditions, enables a very clear idea of the importance of the work to be obtained.

It is impracticable, in the limits of space here available to discuss the tests at length, and the report itself should be examined in detail by those interested in this branch of work. The general conclusion is that rapid tests are not reliable so far as the study of the physical properties of cements are concerned, and that reliable results are only obtainable from longer periods of time. The practical tests are those made by hardening the specimens in air and water under similar conditions to those which obtain in actual use. Under such conditions the standard cements tested gave results which were excellent, and the methods employed in the cases described are models for subsequent use.

The Chimneys of the Exposition Power-Plant.

SOME account was given in these columns last December of the plans which had been made for the concentration of the motive power of the Paris exposition, and a general description of the power-house was then reviewed. We now have accounts in *Le Génie Civil* of the construction work upon one of the great chimneys into which the batteries of boilers will deliver their discharge gases. At the exposition of 1889 there was no general united attempt to collect the power generating plant into a whole, and hence the boilers and engines formed a miscellaneous collection of machines, depending solely upon the individual exhibits for its effect. The great development of the power-house during the past ten years, due to a great extent to the central generation of electrical energy, has made it desirable that the exposition of 1900 should contain an example of such a plant, and it was therefore well decided that the power exhibits should be so arranged as to form a collective as well as an individual feature.

The buildings in which the power generating plant of the exposition is to be housed form the extremities of a portion of the space devoted to the electrical section, which is appropriate enough when it is remembered that three-fourths of the power generated by the engines is to be converted into electricity for lighting alone, and a large portion of the remaining fourth will also be transmitted electrically. The two power houses are identical in design and are on opposite sides of the Champ-de-Mars, there being a building 40 metres in width extending clear across the Champ-de-Mars, 117 metres of each end of this strip forming the area allotted for the boiler houses, one being on the Avenue de Suffren and the other on the Avenue de La Bourdonnais. The one facing on the Avenue de La Bourdonnais will be devoted entirely to the French exhibitors, and it is this one which is furthest advanced in construction.

In each of the great boiler houses the boilers discharge their gases into a central underground flue, which, increasing in dimensions as it proceeds, connects at the extremity of the space on which the house stands, with the great chimney, there being thus two chimneys to be constructed.

As it was desired that these chimneys should be ornamental as well as useful, a competition was opened for designs, and in the specifications laid down for the competitors the general dimensions were not only given, but it was stated that the ornamentation and construction should lend itself to the suitable illumination of the stack. this general lighting of all prominent objects being one of the features of the exposition.

The requirements were for a chimney 80

metres (262 feet) in height, with an internal diameter of 4.50 metres (14.75 feet) at top and 6.20 metres (20.35 feet) at bottom, and as the nature of the ground at the points of erection has been fairly well investigated during the construction of the machinery hall of the exposition of 1889, the design of the foundation could be laid out with a sufficient degree of certainty to make the preparation of plans a definite engineering problem.

A number of designs were submitted in the competition, most of them being architectural in conception, and including copies of Egyptian, gothic or renaissance columns, the one which was accepted being that of MM. Nicou and Demarigny, this being very fully illustrated in *Le Génie Civil*. This design has the merit of retaining the general appearance of a chimney, instead of attempting to make it appear as if it were something else, the decoration being employed merely to emphasize the constructional features. The ornamentation is confined to the upper and lower parts of the chimney, the shaft being left plain. At the bottom the buttresses which reinforce the stability of the base are brought out by effects in colored tiles, and an ornate pattern carried up above the moulding of the pedestal, while above the plain shaft a delicate pattern emphasizes the capital and serves to lighten the effect of the whole.

The work upon the foundation of this large chimney is well shown in the illustrations of the article referred to, the great circular pit having been carried to a depth of 8 metres, at which level the clay strata are encountered, and through which piles are being driven to the quartz sand 16 metres below. The diameter of the foundation is 18 metres (59 feet), and upon the heads of the piles a layer of concrete 5 feet thick is placed to receive the masonry of the base of the chimney. Upon this the superstructure is rising, the materials being hoisted up on the inside of the shaft, and no external scaffolding being required.

The chimney for the other boiler house will be of the same dimensions, but is to be designed entirely by engineers, no decoration being used except as the judgment of the mechanical taste of the constructors may indicate.

Power from Furnace Gases.

In addition to the various communications to the technical press about the application of the discharge gases from blast furnaces in gas engines we now have in the *Zeitschrift des Vereines Deutscher Ingenieure*, a report by Professor Meyer, of Göttingen, upon tests made upon a 60 horse power engine at Differdingen, in Luxemburg, giving the latest and fullest information upon a subject of growing importance.

Herr Meyer first comments upon the general advantages of the gas engine, including the high thermal economy, the freedom from the inconvenience and danger accompanying boilers, and the absence of the labor of handling solid fuel; and he shows, by the use of the Rocour method of the heat-balance applied to the blast furnace, that only about 60 per cent. of the thermal value of the fuel used in a furnace is utilised in the operation of smelting. There remains, therefore, ample unburned fuel in the discharge gases, and this fuel can be utilised to double the advantage in gas engines than by burning under boilers.

The principal objections to the use of furnace gases in gas engines are given by Herr Meyer as follows:

1. Difficult and irregular ignition, low thermal efficiency, and the necessity of large cylinders, on account of the lean quality of the gases.

2. Fouling of the cylinders, excessive wear, due to the dust in the gas, and rapid deterioration of the lubricant, for the same reason.

3. Irregular speed of the engine, due to the unavoidable variation in the pressure of the gas as discharged from the furnace.

4. Difficulty of starting large gas engines.

These points are taken up seriatim by Herr Meyer, and it is shown that with improved methods of ignition, and especially with the use of higher compressions, that the ignition can be made as certain as with richer gas, and that with properly proportioned engines the efficiency can be kept at a high point.

So far as dust is concerned, it is a fact that dust creates almost as much trouble when the gas is burned under boilers as it could do in the cylinders of gas engines, while with reasonable provision for scrubbing the gas, the dust can be removed to an

extent which avoids all serious difficulty from this source.

The irregularities in pressure are readily met by delivering the gas into a holder, which rises and falls with the variations of delivery of gas, and permits a uniform delivery to the motors. The improvements which are constantly being made in the construction of large gas engines render the last objection of little moment, the only difference in respect of starting between engines for furnace gas and those for illuminating gas being the somewhat higher compression used in the former case.

The account of the test of the engine at Differdingen is of especial interest because of the very complete plans which are given of the arrangement of the plant. The scrubbers, pressure regulators, and connections for gas and air, are all well arranged and fully shown, and details of the minor modifications in the construction of the engine are also given. The 60 horse power engine was built by the Berlin-Anhalt Machine Works, and was of the usual four-cycle type, and drove a Schuckert continuous-current dynamo for the lighting of the iron works.

Tests of this engine with illuminating gas showed a capacity of 80 horse power, while with furnace gas the indicated power was 67 H. P., so that 16 per cent. less capacity was the result of the use of the leaner gas. The details of the test are given at length in the original paper, and only the results will here be enumerated; it will be seen that they are remarkably good, considering the conditions. Comparing the indicated power with the brake power, it appears that the mechanical efficiency of the machine was as high as 83 per cent., while the total efficiency of the combined engine and dynamo was about 70 per cent. The calorific value of the gas was determined by Junker's method, except that measurement on the gas holder was substituted for the less accurate method of the small meter generally used with the Junker calorimeter. The average thermal value of the gas was 940 calories per cubic metre (105.6 B. T. U. per cubic foot), and the average consumption per horse-power-hour was 2.32 cubic metres (82 cubic feet), and the thermal efficiency of the engine ranged between 27.4 to 30.2 per cent., the lower figure being when the indicated capacity was 46 H. P., and the best efficiency being when developing 79.5 H. P.

Such results as these show that there is no question about the high possible thermal efficiency of engines using furnace gases. Indeed, the performance of this engine is remarkable for any kind of gas, and the whole trial goes to show that the gas engine has already attained a position where it must be reckoned with on all sides as the coming motor.

The details of Herr Meyer's trials form a most excellent study for use in connection with gas engine tests, and form a valuable guide to those undertaking similar trials elsewhere.

Hot Water in Sewers.

THE too common practice of delivering the hot waste water from manufacturing establishments into city sewers is commented on in a recent issue of the *Gesundheits-Ingenieur*, and a number of points in connection with the effects of the practice are brought out.

The question arose in Germany in connection with the completion of the new sewerage system of the city of Magdeburg, in which the sewerage is delivered into one general collector, from which it is drawn by the pumping machinery for distribution over the area used as a sewage farm. The discharge of hot wastes from factories had been permitted in the old sewers, and the question of the effects of this practice was referred to a medical commission before formulating regulations in regard to the new system.

As it was not desired to forbid the use of the sewers to any establishment the question referred to in the commission was the determination of the maximum degree of temperature which could be permitted in waste discharges without danger to public health, and without material injury to the sewer itself.

With regard to the injury to the sewer, this is caused mainly by the unequal expansion and contraction due to the sudden entrance of hot water, followed by cold, cracks being developed which rapidly widen and weaken the whole structure, besides permitting the seepage of the contents of the sewer into the surrounding soil. A moderate vol-

ume of warm water will also cause the disengagement of foul gases from the matter already in the sewer, besides producing vapor of water to such a degree as to make work in any part of the system impossible. Since modern sewers are usually so built that access may be had to nearly every portion for cleaning and repair this latter becomes an important feature, and it is clearly shown that water of a temperature of about 25° C. (77° F.), will give off enough vapor to cause the clothing of workmen to become uncomfortably wet in a short time.

So far as questions of hygiene are concerned, there is no doubt that the temperature of the sewage should be kept as low as is practicable. In some instances the regulations forbid the discharge of any matter into the sewers which is higher in temperature than that of the contents. When the hot water is pure water of condensation from steam engines it is better to allow it to flow directly into the river rather than into the sewer. It is generally agreed that the action of hot discharges, tending as they do to hasten decomposition of the organic matter in the sewage, is most injurious to public health, and on this account, if on no other, the temperature should be limited to a safe maximum.

Under these circumstances the commission reported that the highest temperature permissible for waste water discharged into the Magdeburg sewers should be 40° C. (104° F.), and if possible this should not be reached.

Apart from the injurious effect of discharge of hot wastes into sewers, the very fact that quantities of heated water are allowed to run away, indicates defective technical arrangements in the factories where this occurs. In nearly every case the heat thus thrown away could be utilized, and instead of being regarded as a loss, it should be considered as a product, and the refuse delivered to the sewer ought to have the heat contained in it absorbed in some profitable direction, without requiring the compulsion of a municipal ordinance.

Superheated Steam.

It is beginning to be generally admitted that superheating is about the best method available for reducing the losses due to cylinder condensation, and the principal differences of opinion are those about the best method of producing and applying the superheated steam. Herr Hubert Hoff has described, in a recent issue of *Stahl und Eisen,* the latest practice in Germany in this line of steam practice, and his paper is well worth examining by those interested in this line of work .

Some of the older superheaters are shown, followed by illustrations of the superheaters of Schwörer, Hering, and Schmidt, and a number of methods of adapting these to boilers of different kinds are shown. The Schmidt engine, for especial use with superheated steam, is also illustrated, and the results of Professor Gutermuth, of Darmstadt, are quoted to show that a steam economy of 10 to 30 per cent. may be obtained with superheating, which is quite within practicable limits.

In this connection Herr Hoff calls attention to the effect of highly heated steam upon the strength of materials, noting that the tests of Rudeloff have proved that the strength of copper is diminished 50 per cent. for an increase in temperature from 16° to 293° C. Ordinary bronze diminishes still more rapidly in strength, but phosphor-bronze retains two-thirds of its strength at 15° C., when heated to 260° C. These facts should be borne in mind in designing pipes and connections to be used with superheated steam, and proper allowance made in determining proportions.

Aluminum for Household Utensils.

When the modern electrical processes for producing aluminum were put into practical and commercial operation, it was expected that an important application of the metal would be for the construction of household utensils, especially for cooking, and in fact many such applications have been made. In France especially, camp utensils of aluminum have been supplied to many regiments in the army, the light weight and supposed freedom from corrosion making the metal far more desirable than tin-plate for this purpose.

In a recent communication to the French Academy M. A. Ditte discussed the objections to aluminum for this purpose, his remarks being very largely based upon the condition in which many of the utensils were found after the return of the troops

from the Madagascar campaign. According to M. Ditte, aluminum is readily attacked by acetic acid in the form of vinegar, and is also acted upon by salt water, and even the portable water-tanks of aluminum used in Madagascar were found to be pitted with holes, showing apparently the action of ordinary drinking water. The insides of cooking vessels were also said to be covered with a greasy coating, and altogether a bad case was made out against the metal.

A very exhaustive response has been made to this paper by a communication to the Academy by M. Moissan, who is certainly well adapted to speak from experience as to the properties of aluminum, and he shows that while many of the facts cited by M. Ditte are true, the conclusions drawn from them are incorrect.

In the first place it is well known that the presence of impurities in the metal greatly decrease its capacity to resist corrosion, and most if not all of the articles served out to the soldiers who went to Madagascar were made from the earlier products of the aluminum works, when the metal was by no means so free from impurities as it now can be had. M. Moissan shows by comparative analyses that commercial samples of aluminum of 1893 contained only about 92 to 93 per cent. of pure metal, there being 5 to 6 per cent. of copper, and usually more than 1 per cent. of iron, while commercial specimens of 1897 contained 97 to 99 per cent. of aluminum, and usually less than 2 per cent. of copper, the iron being below 0.2 per cent., and the silicon below 0.1 per cent.

M. Moissan also calls attention to the important fact that aluminum readily forms an electrolytic couple with almost any other metal, and that especially with iron a corrosive action is readily set up. This fully accounts for the behavior of the metal of the water carts, in which the aluminum tanks were carried in iron frames, and in which therefore the corrosion was undoubtedly due to the electrical action and not to the influence of the contents.

So far as actual experience goes, M. Moissan remarks that during the past three years the cooking in his own household has been entirely performed in utensils of aluminum, and that there has been no evidence whatever of corrosion or of the formation of any coating. These vessels have been heated over gas in summer, and over coals in winter, and have been subjected to the tender mercies of a succession of servants, receiving no especial care, and are yet in excellent condition.

M. Ditte, in a subsequent response, called attention to the fact that some of M. Moissan's points were not well taken, but on the whole the result of the discussion between these eminent experts before a most competent audience, is that with reasonable care, and the use of commercially pure aluminum free from contact with other metals, no danger or inconvenience need be apprehended in using aluminum for household or military utensils.

REVIEW OF THE AMERICAN PRESS

The Efficiency of the Bicycle.

THE active competition between various bicycle manufacturers has led many claims to be advanced as to the superior efficiency of this or that form, and many modifications have been made merely for the purpose of establishing so-called "talking points." Several systematic investigations have been made, however, by men not directly interested in any especial make, and some of the results of these investigations are very interesting.

A paper upon the efficiency of the bicycle, read before the Civil Engineers' Club of Cleveland, by R. H. Fernald, and published in the *Journal of the Association of Engineering Societies,* gives the results of a number of tests of machines under various conditions, and the data and results of these trials as there given form an interesting record.

The apparatus used was similar to that devised by Mr. Mack, and described in connection with previous trials in a paper presented before the American Society of Mechanical Engineers. This apparatus was intended to treat the bicycle, not under road conditions, but simply as a machine, this being at the same time the simplest and the fairest method, since the varying conditions of road trials render it practically impossible to obtain comparable results. The apparatus practically converts the bicycle into a hoisting machine, the hoisting being affected by applying weights to the pedal and causing the machine, as it advances, to lift a weight by drawing on a cord passing back and down over a pulley. An average load of 150 pounds was placed upon the saddle, and the track was formed of the smooth surface of the top of a beam, so that the external resistances were reduced to a minimum, and calibration of those remaining enabled proper correction to be made.

The results obtained were plotted as curves, the abscissas representing gross weights lifted, and the ordinates percentages of efficiency, the efficiency percentage being obtained by dividing the product of the weight lifted into its distance by the weight applied to the pedal in its distance. Naturally one of the first tests discussed is that of the relative efficiencies of chainless and chain wheels. While it was found difficult to be sure that all other conditions were identical, yet with every care in this respect it appeared that the chainless wheel showed a somewhat higher efficiency for small loads, while for heavier loads the efficiencies were practically the same.

Another comparison of importance was that between different grades of the same make of bicycle. Here the difference was marked and consistent, the curves showing a steady divergence in favor of the higher grade wheel. A very marked difference also appeared between a regular wheel and a special racing bicycle of the same make, prepared for the use of a man riding for the makers.

When the medium and the cheap bicycles are compared very little difference appears between them, and indeed one result of these trials is the demonstration of the excellent efficiency of all the wheels tested. Even a $25 bicycle showed an efficiency of about 92 per cent., while the difference between a dirty wheel and the same one cleaned is only about 90 to 96 per cent.

An interesting point was the marked improvement made in the efficiency of a good wheel after a moderate amount of use. Tests of a new machine showed many irregularities in the curve, showing that, although the wheel was of high grade, there were irregularities in the chain, sprockets, and bearings. After the same wheel had been ridden a few hundred miles it was again placed upon the testing machine, and showed a much smoother action as well as a higher efficiency curve, evidently due to the wearing down of the original imperfections. This is only what might have been expected, since the analogy of all other machines shows a "limbering up" with a moderate degree of careful use.

Theory indicates that easier running should be obtained with larger sprocket wheels, and this view is confirmed by the trials. The substitution of nine for eight teeth in the rear sprocket made but little difference in the efficiency, but the use of an eight-tooth rear sprocket gave an efficiency of 97.5 per cent. of that of the ten-tooth.

Tests upon tires showed greater variations than any others, differences in the inflation giving marked differences in the curves, the greater efficiency being naturally found with the strongest inflation.

While these tests were far from being complete they give much very useful information about this much-used machine, and the most gratifying thing about them is the generally good showing made by all the wheels, no one of them failing to reach 90 per cent. efficiency at full load, even under most unfavorable conditions.

A Great Electric Plant.

WHAT is undoubtedly the greatest isolated electric light plant in the world is that installed and in operation in the Waldorf-Astoria Hotel in New York, of which a very full description is given in *Power*, from which an abstract is here taken:

"If you were told of a steam plant with a boiler capacity of 4,000 horse power, with electric generators capable of developing 1,500 kilowatts, wtih 25,000 electric lights, with a refrigerating plant having a cooling capacity equal to the melting of 150 tons of ice per day, with pumps sufficient to handle the water supply for a city of 400,000 inhabitants, a plant which has 152 steam and 102 water cylinders, and 56 electric motors, and a force of 116 men in the engineers' department, would it occur to you that it was simply the mechanical plant of a hotel?"

It is a characteristic feature of all American hotels and business buildings that they contain machinery and power to an extent unknown in other parts of the world, and one of the features of an American city which impresses visiting foreigners is the evidence of power machinery in the tall chimneys and escaping steam from the tops of buildings devoted to residence and business purposes. The climax of this feature is undoubtedly reached in the Waldorf-Astoria plant. A description of the plant would consist merely of an enumeration of a list of engines and machines, conveying rather an idea of the products of a great machine works than of the contents of the basement of a hotel, but some general idea of the character of the plant may be obtained from the following general description:

Steam is generated in seven Babcock and Wilcox boilers, aggregating 2,600 horse-power in the Astor Court plant, supplemented by 1,000 horse-power from the Waldorf plant when steam heating is required. These boilers supply six Allis engines, aggregating more than 1,800 horse-power, built on the rolling mill style and connected direct to four 250-kilowatt and two 100-kilowatt multipolar generators, forming the largest isolated installation in the world. The larger generators are guaranteed for 93¼ per cent. commercial efficiency at full load; 92½ per cent. at three-quarter load, and 91½ per cent. at half load, and the smaller machines are guaranteed at 1 per cent. less efficiency at each point. All the machines are guaranteed to carry full load without sparking, the maximum rise in temperature being 85° F. at the commutator, and 70° F. elsewhere. They were built by the Walker Manufacturing Company. A storage battery of 56 cells is used to equalize the load.

Numerous electric motors, ranging from 90 horse power down, are scattered all over the plant, motors even being used to drive the coffee mills, and all being direct connected. The elevators are driven by electrcity, as are all the machines in the laundry, and the ease with which electric power can be obtained renders it available for every power purpose imaginable. Three 50-ton De La Vergne refrigerating machines are required for the cold storage plant, and a pumping plant like that of a great city waterworks completes the actual power portion of the equipment.

The ventilating plant is a noteworthy portion of the establishment, providing as it does for the movement of 14,000,000 cubic feet of air per hour through the four lower floors of the hotel, these being the rooms used for the restaurants, cafés, dining rooms, concert halls and ballrooms. Five Sturtevant blowers are employed for

this purpose, one of 12 feet diameter of wheel and four of 10 feet.

The whole plant contains a multitude of details impossible to enumerate, but necessary to make up the effective whole, and a visit to the power rooms is one of the sights of the hotel; an observation gallery being provided for the purpose of enabling the engine room to be visited and observed in a convenient manner.

Apart from the direct interest which this great plant excites in connection with the hotel itself, it is an important example of the manner in which engineering features are becoming a portion of the daily life of everyone. Formerly steam engines and boilers formed portions only of manufacturing establishments, and electric machinery was seen only in central stations and power houses. To-day power plants are in the basements of nearly all large buildings and many small ones, and one is not surprised to see steam issuing from the top of any building. Even where steam is not used the convenient gas engine is frequently installed, and the general rule of doing everything possible by power is everywhere observed.

Problems in Telephone Engineering.

THE very fact that the term "engineering" can be applied to telephone work is evidence of the extent to which the work of the engineer has spread over nearly every branch of industry, and it is under this very suggestive title that Mr. Theodore Spencer has contributed a most interesting paper to the *Proceedings* of the Engineers' Club of Philadelphia.

Mr. Spencer's paper deals very largely with the exchange system, and with the manner in which the "talking" and "signaling" systems are operated, including the use of advisory incandescent lamps, by means of which the operators are automatically informed of the completion of the connection, and of many other details of the work.

"The present telephone exchange consists of a number of central offices connected by trunk lines; each central office is equipped with multiple switchboards and with power plants for furnishing power to energize transmitters at subscribers' stations. Associated with this talking is the automatic signaling system from subscribers' stations to central offices and between central offices, the signals being operated from the same power plant that is used to energize transmitters."

The extreme sensitiveness of the telephone receiver requires that special precautions be taken to avoid inductive disturbances. Mr. Spencer gives, as an example of the sensitiveness of the telephone, the statement that one foot-pound of energy applied to a telephone receiver with no loss in conversion would produce a continuous audible sound for over three thousand years! The very small amount of energy required, therefore renders high efficiency, as commonly understood, altogether unnecessary, and the term efficiency, as applied in telephone practice, merely refers to the completeness with which conversation can be carried on.

Mr. Spencer discusses the question of the possibility of conducting telephone communication between the United States and England, and shows that even if the electrical difficulties are overcome the difference in time would render the telephone efficiency very low. The records show that the great bulk of telephone messages are sent during that limited portion of the day known as "business hours." Owing to the five hours' difference in time between London and New York, the London business day is about two-thirds over when that in New York is just beginning, and the result is that telephone communication, even were it possible, would be practically limited to the few hours during which the business days overlap. The time relations between various places are analysed in connection with this idea, by means of graphical diagrams, and it is shown that, for commercial purposes at least, the telephone is best adapted for use within areas no greater than that of the United States.

"It is an old simile to compare a telephone line to a door. The comparison is a reasonably exact one: both permit the entrance of business and consequently of profits, to the telephone subscriber. Under present conditions a large part of the daily business of a city is transacted on the telephone. Would it be wise for a business man to restrict his trade by forcing all his visitors to pass through a single narrow

door that was constantly in use by persons passing in the opposite direction? And is it wise to insist that incoming orders and information shall be forced through one telephone line that is possibly already overcrowded with outgoing calls?"

The question of "particular person" service is one which is of importance in connection with telephone work. It is estimated that about 75 per cent. of the local business transmitted on the telephone is to any one at an office. At greater distances the business transmitted to particular individuals is almost 100 per cent. This is especially the case with the long distance telephone, conversation over which is generally unsatisfactory on important affairs unless there is a personal acquaintance between the persons talking.

"While it is always proper to criticise the shortcomings of any service, in criticising the service given by the telephone system the extraordinary usefulness and rapid development of the apparatus and plant must be considered. Aside from questions like the general ones of particular person service, improvement in this, as in other industrial undertakings, can only be reached by steady and patient development in the detail of apparatus and operating."

Compressed-Air Motors in New York.

NOTWITHSTANDING the success which has attended the use of the underground electric system in New York city for the propulsion of street cars, there are many instances where it is desirable to have a self-contained source of power, which can be operated on any existing road without the connection with any conductor, cable or other outside transmission. For this purpose compressed air is to be adopted, and from the *Street Railway Journal* we take some details of the system of the American Air Power Company as it is to be applied on certain cross-town railways.

As is the case with electric motors, the engines are to be contained in the trucks, a complete truck having a double cylinder air engine connected to each axle. The axles are straight, as in the case of ordinary electric motor cars, the engines connecting to pinion shafts geared about two to one to the truck axles, and the motors and gearing all being enclosed in a dust-proof case containing oil. The use of side rods is dispensed with, each axle being driven independently, one by two high-pressure motors, the other by two low-pressure motors. The principle closely followed in the design is that of the general standard street railway practice as developed on electric roads, retaining the standard wheels, axles, trucks and car bodies, as it is believed that these have now reached a form in which the expense of maintenance is a minimum. Following also electric practice the controller is designed with two handles, one for speed and the other for direction, and it is easy for one familiar with the operation of an electric motor to control one operated by compressed air.

The compressed air is contained in seamless steel bottles, placed under the seats. These bottles are 21 feet 6 inches long and 9¼ inches in outside diameter, and have a factor of safety of three, the initial pressure being 2,400 pounds. From this pressure the air is reduced to 320 pounds per square inch, passing through a hot water heater on its way to the reducing valve. The water in the heater is at a temperature of 400° F., and a portion of water at this temperature is also injected into the air in order to supply moisture.

This degree of heating is intended to prevent the production of excessive cold in the exhaust, while the added moisture assists in packing the joints, dry air being difficult to manage in this respect, while the expansion of the moisture in the cylinders assists in maintaining the pressure towards the end of the stroke.

The controller operates both by varying the cut-off and by throttling, a compound handle being used, the cut-off being set at as early a point as will give the desired power, and the control then effected by the throttle, while for emergency power later cut-offs are available.

A powerful four-stage air compressor, of the Ingersoll-Sergeant make, has been constructed for use at the charging station, the capacity being 1,000 horse-power. The machine consists of a vertical cross-compound engine, built by E. P. Allis Company, with cylinders 32 and 68 inches diameter by 60 inches stroke, while the air compressor is placed directly beneath,

and has four cylinders, the low pressure being 46 inches, the first intermediate 24 inches, the second intermediate 14 inches, and the high pressure cylinder 6 inches diameter, the stroke of all being 60 inches. These cylinders are all single-acting and are water-jacketted, and inter-coolers are placed betwen them. The whole machine is 60 feet in height, from which some idea of the magnitude of the plant may be obtained.

The system differs in many respects from those used in Europe, notably in the form of motors employed, in the method of heating, and in the high pressure used. By the use of a pressure of 2,400 pounds it is planned to operate trips of fifteen miles with such a charge as can be contained in the flasks under the seats, and there is reserve capacity sufficient for an increase up to double this if necessary. The main charging reservoir consists of a large number of the same type of flasks as are used in the cars, but carried in a rack and piped to a manifold, from which the air from the compressor is switched to any bank of reservoirs desired. This reservoir system is piped to the charging room, where are also nozzles for charging the heaters with hot water, so that a car, when run into the charging room, can be connected up and charged with little delay.

The whole system seems to have been worked out very carefully, and although improvements will doubtless suggest themselves after a period of practical experience, there seems little doubt that this important and initial plant in New York will prove a mechanical and commercial success.

Municipal Water Meters.

THE utter recklessness with which many people allow water to be wasted has become so general that cities which profess to pay any regard to good management are compelled to take measures to prevent waste, and to throw the burden of excessive use of water where it belongs—upon the immediate users and not upon the community at large. As this is a matter which is attracting much attention in various places the experience of the city of Richmond, Va., discussed at the convention of the American Waterworks Association, and published in the *Engineering Record,* is of much interest.

The popular opinion about water meters is that they place a premium upon filth and uncleanliness, and that as soon as water is paid for by measure people will become penurious in its use. It is useless to tell people that this is not the case, but the experience of Richmond may be allowed to speak for itself.

Originally provided with a gravity supply, increasing population and demands caused this to be supplemented by an intermediate and a high-service supply, but the consumption per capita increased from 45 gallons per day in 1870 to 92 gallons in 1880, and to 168 gallons in 1890. Citizens living on the high points had no water on the second floors of their houses during the day, and the risk from fire for want of pressure was serious.

Estimates showed that $270,000 would be necessary for the additional mains, but the chief engineer, Mr. Bolling, maintained that the true remedy was the checking of the waste by the introduction of meters. The usual opposition followed, but the urgency of the case prevailed, and in the spring of 1897 $15,000 were appropriated for meters, which were promptly installed. By the end of the year the pressure at the high points had increased 40 per cent., and the result was the introduction of meters in the low district, where after a year the pressure was found to have been increased 100 per cent. All complaint for want of water had ceased, and the pressure was the same at those points which would have been obtained by expending $270,000 and assuming an annual expense of $17,000. Prior to placing the meters the water-power pumps were insufficient to keep up the supply, and it was often necessary to run the steam pump, which increased the cost of pumping $2,500 per annum, while since the past eighteen months the steam pump has not been used at all. The total expenditure for meters was $20,000, while the entire annual saving is $19,500. The per capita daily consumption for 1898 was 99 gallons, a reduction of 41 per cent. from that of 1890, and the quantity of water used is 27 per cent. less now than in 1890.

This is a simple story, but it may carry an important lesson to many greater cities

which are wrestling with the problem of increasing wastefulness, overworked engines, insufficient reservoir capacity, and all the abuses which have grown up under the old system. Those who fear that idle bugbear, injury to public health, due to insufficient use of water, will find that it exists only in the imagination, while other dangers can be invited by a neglected water supply which are far more real and pressing.

Thus the fire risk may be reduced very greatly by the increased pressure and fuller supply which the restriction of waste makes possible. Again, in many cities the introduction of proper filtration and sedimentation systems is rendered prohibitive in cost by reason of the excessive amount of water to be treated, while the introduction of meters may render an ample and pure supply available within reasonable limits of cost. The introduction of the system of selling water by measurement may be slow, but it must come if waste is to be stopped and public health and safety insured.

The Structural Design of Buildings.

THE general change which has entered into the structural details of buildings with the use of steel frame construction has made the work of the engineer in building construction a far more important feature than formerly, and at the present time many buildings practically realize the old idea of the countryman; they are built first and then have "the architecture put on to them." A paper upon some features of the structural design of buildings, by Professor Wm. H. Burr, in the *Journal of the Franklin Institute*, deals with the engineer's side of the question.

Beginning with the question of foundations, Professor Burr showed that formerly the questions of depth and character of foundations were left almost entirely to the judgment of the building constructors, but that with the heavy loads now imposed by the modern skyscrapers all this has been changed. "The own weight of such buildings is sufficient to impose upon the foundations loads per square foot as high as it is safe to place on foundation supports designed and built under the most competent engineering supervision. Similarly the supports of the superstructure of the building, including beams, girders and columns, must be designed so as to reach the highest engineering excellence attained in the structural practice of the civil engineer. The tall office buildings of the present day, commonly known as skyscrapers, are now carried on frameworks of steel which form a component part of the building itself. The great height to which these buildings rise make it imperative that wind loads should be considered in their design as well as those which act in a vertical direction. Concisely put, the structural design and the construction of a modern high building requires the application of the most advanced engineering principles, and neither superstructure nor foundation can be satisfactorily designed or constructed except under the best engineering supervision, from the main features to the smallest details."

After classifying foundations into the three classes represented by those resting directly upon the earth or sand, those resting upon groups of piles, and those carried down to bed rock by the pneumatic caisson, Professor Burr cites existing buildings which form good examples of the various methods, and shows how the skill of the engineer must enter into the judgment in selecting the best kind of foundation for any given instance.

Coming to the superstructure, the modern steel framing is described, and the points wherein it differs from other forms of structural work are brought out. In bridge and other out-door work open columns are generally used, in order that access may be had to all parts for painting. In building construction, however, the majority of the sections are closed, and it may be stated with confidence, according to Professor Burr, that when the metal work of building columns is well painted with three coats of paint, applied to thoroughly clean surfaces, and when these columns receive such protection as it is perfectly feasible to attain in modern building construction, the question of possible corrosion with the lapse of time is one of very subordinate importance.

The questions of correct column proportion are well-known and simple in application, but to this must be added judgment

in using such forms as will permit of the construction of efficient details, particularly where the beams and girders are attached to the columns. These points are all attainable within the limits of good structural practice and at reasonable prices. Continuity should be secured in the columns at all joints, and eccentric loading especially avoided. This can readily be done with steel columns, but it is impossible to prevent eccentric applications of loads with cast-iron columns, not only because of the form of connections employed, but also because of the irregular sections. Professor Burr objects to the use of cast-iron columns in any case, and shows that if the same degree of safety is to be secured the structural steel column will be the cheapest, as it is in all respects the best.

The importance of thorough bracing against the pressure of the wind is also emphasized, and its neglect in many instances commented on, which, in view of the discussion of the subject in Europe is a matter of peculiar interest at the present time.

A Commercial Liquid Air Plant.

Up to about two years ago air had been liquefied only in minute quantities in a few laboratories, at a cost which bore no relation whatever to the quantity or value of the product. To-day there is being erected in New York a plant for the commercial manufacture of liquid air, with a capacity of 1,500 gallons per day.

Details of this plant are given in a recent issue of *Engineering News*, the apparatus being that of the General Liquid Air and Refrigerating Company, and many illustrations render the construction and operation of the apparatus clear.

The plant is merely a steam power refrigerating plant, utilizing the expansion of compressed air to produce a low temperature, and causing this cold air to react upon itself until a temperature is reached so low that liquefaction occurs.

Two independent two-stage air compressors of the Ingersoll-Sergeant type are used with intercoolers between the cylinders, the two forming a four-stage compressing plant. After the air has thus been been raised to a pressure of 1,200 pounds per square inch it is passed through a separator to remove oil and moisture, after which it is delivered into a system of coils in a brine tank. A second system of coils is also contained in the same tank, and into these expanded air is conducted, the cold thus produced lowering the temperature of the high pressure air in the first system.

The cold compressed air then goes to the liquefier, which is a pair of tanks containing spiral coils through which the air passes. The coils are in a double series, and by means of a reducing valve the air is permitted to expand in one series to a pressure of about 300 pounds, and in so doing cools the air in the other set, and by a continuous repetition of this action the temperature is lowered until the critical point is reached, and the liquefied air drops into the collecting chamber beneath.

Judging from the behaviour of this apparatus, the action indicates the temperature is gradually being reduced towards some minimum, which, so far as present indications go, is remarkably near the hypothetical absolute zero. From the results which have been obtained during the testing of the compressors it may be expected that the air will be actually solidified.

In the same account a description is given of the reservoirs in which the liquefied air may be carried and transported with little loss. These reservoirs consist of 40 gallon tanks surrounded by outer tanks, the intermediate space being kept cold automatically by the escape of a small quantity of the liquid air from the inner vessel. The whole is packed in a wicker basket, the space between being filled with some non-conducting material, and the loss by warming is thus reduced to a minimum.

Although the practical uses of liquid air are as yet very limited, the fact that it is thought a good business proposition to construct a plant of this magnitude shows that there are possibilities of a commercial nature ahead. One application is that of using the power of volatilized liquid air to operate a cooling fan, the cold exhaust of the motor being delivered into the current produced by the fan, thus supplying cold fresh air during hot weather, and in hospitals and sick rooms especially this apparatus should be most effective. Many other applications have been given in Professor Thomson's paper in the May issue of

this magazine, and there is little doubt that there will be, for the present, at least, a demand for liquid air for experiments.

As the plant above described has not yet been operated except in a preliminary manner, data are lacking from which to determine the cost of the product. and upon this cost much will depend as to possible applications. There is little doubt that the cost will be regulated largely by the law of demand and supply, and that a sufficiently large demand will be brought within commercial limits.

Compressed Air to Save Ships.

THE uses of compressed air are many and important, but in a recent issue of the *American Machinist* Mr. Frank Richards offers yet another application. The wrecking of the steamship Paris on the coast of Cornwall and the difficulties encountered in attempting to save her while a number of her compartments forward are filled with water, lead Mr. Richards to suggest the applicability of compressed air.

"There is a means of expelling the water from the filled compartments so obvious, and so certainly effective that it seems unaccountable that some engineer has not suggested it before this. Close the hatches of the flooded compartments and drive the water out by forcing air in. It would not make the slightest difference how big the holes might be in the bottom, as the water would be expelled and kept out on the same principle as in the old-fashioned diving bell."

This suggestion carries with it a much larger and more important one, namely, the use of air pumps instead of water pumps to save a leaking ship while afloat. As Mr. Richards well remarks, the work of trying to pump out a leaky ship is not only enormously wasted while it is going on, but it is never finished. If, however, the water leaking into a compartment of a ship be expelled by pumping air into the space, the work is done so soon as the compartment is filled with air down to the level of the leak. After that point is reached the ship is safe, no matter how large the hole, and no further pumping is necessary.

"Obviously the lesson which the incident of the hour should enforce is that the air compressor should be employed, not merely for the present emergency, but universally in ships as a cheaper and vastly more efficient protection. The use of compressed air for water expulsion should be provided for in the construction of the ship, especially in the staying of the decks and bulkheads, and in the construction of an occasional air lock instead of single doors or hatches. No elaborate system of piping would be required, as air hose would be preferable, and could be carried wherever wanted. The compressors would cost no more than the pumps which they would supplant. In the navy, where the employment of compressed air for auxiliary power transmission is still debated, this one use of air should be an overwhelming argument for its installation."

THE ENGINEERING INDEX

INTRODUCTORY.

The object of this Index is to supply all persons interested in engineering and industrial pursuits with, first, an expert descriptive summary clearly indicating the character and purpose of the leading articles published currently in the established technical journals of the United States, Great Britain, and the Continent—in all languages; and, secondly, an inexpensive means of readily obtaining such portions of this literature as may be desired.

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THE PUBLICATIONS REGULARLY REVIEWED AND INDEXED.

The titles and addresses of the journals regularly reviewed are given here in full, but only abbreviated titles are used in the Index. In the list below, *w* indicates a weekly publication, *b-w*, a bi-weekly, *s-w*, a semi-weekly, *m*, a monthly, *b-m*, a bi-monthly, *qr*, a quarterly, *s-q*, semi-quarterly, etc. Other abbreviations used in the Index are: Ill—Illustrated; W—Words; Anon—Anonymous.

American Architect. *w.* Boston, U. S. A.
American Electrician. *m.* New York.
Am. Engineer and Railroad Journal. *m.* New York.
American Gas Light Journal. *w.* New York.
American Geologist. *m.* Minneapolis, U. S. A.
American Journal of Science. *m.* New Haven, Conn.
American Machinist. *w.* New York.
Am. Manufacturer and Iron World. *w.* Pittsburg.
American Shipbuilder. *w.* New York.
Am. Soc. of Irrigation Engineers. *qr.* Denver.
Annales des Ponts et Chaussées. *m.* Paris.
Architect. *w.* London.
Architectural Record. *q.* New York.
Architectural Review. *s-q.* Boston, U. S. A.
Architecture and Building. *w.* New York.
Architektonische Rundschau. *m.* Stuttgart.
Australian Mining Standard. *w.* Sydney.
Automotor and Horseless Vehicle Jour. *m.* London.
Berg-und Hüttenmännische Zeitung. *w.* Berlin.
Brick Builder. *m.* Boston, Mass.
Bridges. *m.* Chicago.
British Architect. *w.* London.
Builder. *w.* London.
Bulletin Am. Iron and Steel Asso. *w.* Phila.
Bulletin de la Société d'Encouragement. *m.* Paris.
Bulletin of Dept. of Labor. *b-m.* Washington.
Bulletin of the Univ. of Wisconsin, Madison, U.S.A.
Bull. Int. Railway Congress. *m.* Brussels.
California Architect. *m.* San Francisco.
Canadian Architect. *m.* Toronto.
Canadian Electrical News. *m.* Toronto.
Canadian Engineer. *m.* Montreal.
Canadian Mining Review. *m.* Ottawa.
Chem. Met. Soc. of S. Africa. *m.* Johannesburg.
Colliery Guardian. *w.* London.
Compressed Air. *m.* New York.
Comptes Rendus de l'Acad. des Sciences. *w.* Paris.
Consular Reports. *m.* Washington.
Contemporary Review. *m.* London.
Deutsche Bauzeitung. *b-w.* Berlin.
Dingler's Polytechnisches Journal. *w.* Stuttgart.
Domestic Engineering. *m.* Chicago.
Eclairage Electrique. *w.* Paris.
Electrical Engineer. *w.* London.
Electrical Engineering. *m.* Chicago, Ill.
Electrical Review. *w.* London.
Electrical Review. *w.* New York.
Electrical World. *w.* New York.
Electrician. *w.* London.
Electricien. *w.* Paris.
Electricity. *w.* London.
Electricity. *w.* New York.
Elektrochemische Rundschau. *b-m.* Frankfurt.
Elektrochemische Zeitschrift. *m.* Berlin.
Elektrotechnisches Echo. *w.* Magdeburg.
Electrotechniker. *b-m.* Vienna.

Elektrotechnischer Anzeiger. *s-w.* Berlin.
Elektrotechnische Zeitschrift. *w.* Berlin.
Elettricita, *w.* Milan.
Engineer. *w.* London.
Engineer. *s-m.* Cleveland, U. S. A.
Engineers' Gazette. *m.* London.
Engineering. *w.* London.
Engineering Assn. of the South. Nashville, U.S.A.
Engineering and Mining Journal. *w.* New York.
Engineering Journal. *s. an.* Stanford Univ., Cal.
Engineering Magazine. *m.* New York & London.
Engineering News. *w.* New York.
Engineering Record. *w.* New York.
Eng. Soc. of the School of Prac. Sci. Toronto.
Eng. Soc. of Western Penn'a. *m.* Pittsburg, U.S.A.
Fire and Water. *w.* New York.
Foundry. *m.* Detroit.
Gas Engineers' Mag. *m.* Birmingham.
Gas World. *w.* London.
Génie Civil. *w.* Paris.
Gesundheits-Ingenieur. *s-m.* München.
Giorn. Dei Lav. Pubb. e d. Str. Ferr. *w.* Rome.
Glaser's Ann. f. Gewerbe & Bauwesen. *s-m.* Berlin.
Heating and Ventilating. *m.* New York.
Horseless Age. *w.* New York.
Ice and Refrigeration. *m.* New York.
Ill. Carpenter and Builder. *w.* London.
Illinois Soc. of Engs and Surveyors. Peoria, U.S.A.
India Rubber World. *m.* New York.
Indian and Eastern Engineer. *w.* Calcutta.
Indian Engineering. *w.* Calcutta.
Industries and Iron. *w.* London.
Inland Architect. *m.* Chicago.
Iron Age. *w.* New York.
Iron and Coal Trades Review. *w.* London.
Iron & Steel Trades Journal. *w.* London.
Iron Trade Review. *w.* Cleveland.
Jour. Am. Soc. Naval Engineers. *qr.* Wash., D. C.
Journal Assn. Eng. Societies. *m.* Phila., Pa.
Journal of Electricity. *m* San Francisco.
Journal Franklin Institute. *m.* Philadelphia.
Journal of Gas Lighting. *w.* London.
Jour. N. E. Waterw. Assoc. *qr.* New London, Conn.
Journal Royal Inst. of Brit. Arch. *s-qr.* London.
Journal of Sanitary Institute. *qr.* London.
Journal of the Society of Arts. *w.* London.
Journal of U. S. Artillery. *b-m.* Fort Monroe, Va.
Journal Western Soc. of Eng. *b-m.* Chicago, Ill.
Kansas University Quarterly. *qr.* Lawrence, Kans.
La Ingenieria. *m.* Buenos Aires, Argentina.
L'Energie Electrique. *w.* Paris.
Locomotive. *m.* Hartford, U. S. A.
Locomotive Engineering. *m.* New York.
Machinery. *m.* London.
Machinery. *m.* New York.
Marine Engineer. *m.* London.
Marine Engineering. *m.* New York.
Marine Review. *w.* Cleveland, U. S. A.
Master Steam Fitter. *m.* Chicago.
Mechanical World. *w.* London.
Mechanical Engineer. *w.* Manchester.
Mem. de la Soc. des Ing. Civils de France. *m.* Paris.
Metal Worker. *w.* New York.
Mines and Minerals. *m.* Scranton, U. S. A.
Mining and Sci. Press. *w.* San Francisco, U.S.A.
Mining Journal. *w.* London.
Mining Reporter. *w.* Denver, U. S. A.
Mitt. aus d. Kgl. Tech. Versuchsanst. Berlin.
Mittheilungen des Vereines für die Förderung des Local- und Strassenbahnwesens. *m.* Vienna.
Modern Machinery. *m.* Chicago.
Moniteur des Architectes. *m.* Paris.
Moniteur Industriel. *w.* Paris.
Municipal Affairs. *qr.* New York.
Municipal Engineering. *m.* Indianapolis, U. S. A.
National Builder. *m.* Chicago.
Nature. *w.* London.
Nature. *w.* Paris.
New Zealand Mines Record. *m.* Wellington, N. Z.
Nineteenth Century. *m.* London.
Oest. Monatsschr. f. d. Oeff. Baudienst. *m.* Vienna.
Oest. Zeitschr. f. Berg- & Hüttenwesen *w.* Vienna.
Ores and Metals. *w.* Denver, Colo.
Plumber and Decorator. *m.* London.
Popular Science Monthly. *m.* New York.
Power. *m.* New York.
Practical Engineer. *w.* London.
Pro. Am. Soc. Civil Engineers. *m.* New York
Proceedings Engineers' Club. *qr.* Phila.
Proceedings of Central Railway Club.
Pro. of Purdue Soc. of C. E. *yr.* La Fayette, U.S.A.
Progressive Age. *s-m.* New York.
Railroad Car Journal. *m.* New York.
Railroad Gazette. *w.* New York.
Railway Age. *w.* Chicago.
Railway Magazine. *m.* New York.
Railway Master Mechanic. *m.* Chicago.
Railway & Engineering Review. *w.* Chicago.
Railway World. *m.* London.
Review of Reviews. *m.* New York.
Revista de Obras Públicas. *w.* Madrid.
Revue de Mécanique. *m.* Paris.
Revue Gen. des Chemins de Fer. *m.* Paris.
Revue Technique. *b-m.* Paris.
Revue Universelle des Mines. *m.* Liége.
Rivista Marittima. *m.* Rome.
Sanitarian. *m.* Brooklyn, U. S. A.
Sanitary Plumber. *s-m.* New York.
Sanitary Record. *m.* London.
School of Mines Quarterly. New York.
Schweizerische Bauzeitung. *w.* zürich
Scientific American. *w.* New York.
Scientific Am. Supplement. *w.* New York.
Seaboard. *w.* New York.
Sibley Journal of Eng. *m.* Ithaca, U. S. A.
Stahl und Eisen. *s-m.* Düsseldorf.
Steamship. *m.* Leith, Scotland.
Stevens' Indicator. *qr.* Hoboken, U. S A.
Stone. *m.* New York.
Street Railway Journal. *m.* New York.
Street Railway Review. *m.* Chicago, Ill.
Technology Quarterly. Boston.
Terrestrial Magnetism. *qr.* Cincinnati, O.
Trans. Assn. C. E. of Cornell Univ. Ithaca, U. S. A.
Trans. Am. Ins. Electrical Eng. *m.* w York.
Trans. Am. Ins. of Mining Eng. New York.
Trans. Am. Soc. of Civil Engineers. *m.* New York.
Trans. Am. Soc. of Heat. & Ven. Engrs. New York.
Trans. Am. Soc. Mech. Engineers. New York.
Transport. *w.* London.
Western Electrician. *w.* Chicago.
Western Railway Club Pro. Chicago.
Wiener Bauindustrie Zeitung. *w.* Vienna.
Wisconsin Engineer. *qr.* Madison, Wis.
Yale Scientific Monthly. *m.* New Haven, U. S. A.
Year Book of Soc. of Engs. Univ. of Minn.
Zeitschr. d. Oest. Ing. u. Arch. Ver. *w.* Vienna.
Zeitschr. d. Ver. Deutcher Ingen. *w.* Berlin.
Zeitschrift für Elektrochemie. *s-m.* Halle a. S.
Zeitschrift für Elektrotechnik. *s-m.* Halle a. S.

ARCHITECTURAL ENGINEERING

CONSTRUCTION.

Exposition.

The Buildings of the Paris Exposition of 1900. Jacques Boyer. The first paper describes the buildings on the Champs Elysees and the Champ de Mars, giving many illustrations showing the methods of erecting the structural framings. 3000 w. Engineering Magazine—June, 1899. No. 27897 B.

Fire-proofing.

Simple Rules for Figuring the Strength of Terra-Cotta Arches. Henri G. Chatain and W. M. Everett. A statement of facts and principles with as little mathematics as possible. Ill. 1600 w. Br Build—April, 1899. No. 27358 C.

Library.

The New Free Public Library, Jersey City, N. J. Illustrates and describes a large library building. 1400 w. Eng Rec—May 20, 1899. No. 27700.

Stable Construction.

The Strawbridge Stable, Germantown, Philadelphia, Pa. Illustrates and describes the remodeling of an old stable. 2000 w. Eng Rec—May 27, 1899. No. 27791.

HEATING AND VENTILATION.

Blowers.

Rating and Capacity of Blowers. Alton D. Adams. Notes the disagreement in rated capacities between blowers of the same size and different makes, and compares the several ratings as to air pressure, delivery and power of the same blower with each other and the known laws governing the movement of air. 2000 w. Arch & Build—May 27, 1899. Serial. 1st part No. 27782.

Exhaust Heating.

Heating with Exhaust Steam (Ueber Abdampfheizungen.) Hermann Fischel. With plans of various installations showing the method of using high-pressure steam in connection with a reducing valve in the same system as exhaust steam, when necessary. 3500 w. Zeitschr d Ver Deutscher Ing—May 6, 1899. No. 27821 D.

Furnace.

Hot Air Furnace. Martin L. Kaiser. Special prize essay. Illustrated description of method of school-house heating under conditions specified in a competition. 3500 w. Met Work—April 29, 1899. No. 27356.

Hospitals.

A Model Hospital. Frederick Baumann. Discusses the principles that should govern hospital erection, with special reference to the heating and ventilation. 2500 w. In Arch't—May, 1899. No. 27673 F.

School.

Ventilation and Heating of a New York School. Illustrates and describes an interesting plant in a New York City school. The building is heated by direct radiation. 2000 w. Eng Rec—May 27, 1899. No. 27792.

Steam Heating.

Gravity Steam Heating Problems. Illustrated description of the method of solving a number of questions which arose during the installation of a plenum system in a British school-house. 1500 w. Eng Rec—May 6, 1899. No. 27511.

Ventilation.

Ventilation. R. H. Smith. Consideration of the methods and principles of the ventilation of buildings. 2800 w. Engr, Lond—May 5, 1899. No. 27612 A.

PLUMBING AND GAS FITTING.

Gas Fitting.

Gas Fitting as Required in Massachusetts. Illustrations which show methods of doing work in accordance with the new law licensing gasfitters and supervising the business of gas-fitting in the city of Boston. 150 w. Dom Engng—May, 1899. No. 27676 C.

Swimming Bath.

The New York Athletic Club's Swimming Bath. Illustrated description of a large tank built under difficult conditions. 2000 w. Eng Rec—May 20, 1899. No. 27701.

Thawing.

See Electrical Engineering, Heating.

MISCELLANY.

Acoustics.

The Acoustic Properties of Brick, Tile and Terra Cotta. Calls attention to the capabilities of these materials in assisting and modifying sound. 1500 w. Clay Rec—May 12, 1899. No. 27743.

Baths.

Public Douche Baths at Rouen and Paris (Les Bains-Douches à Bon Marché à Rouen et à Paris.) Paul Sarrey. A description of the inexpensive buildings and apparatus which have been found most effective in the promotion of public health and cleanliness in France. 3000 w. 1 plate. Genie Civil—May 6, 1899. No. 27805 D.

Painting.

Sanitary Painting. A. G. White. Ad-

dress before the Master House Painters of England and Wales. The relation of painting to the health and life of buildings. 2000 w. Sci Am Sup—May 6, 1899. No. 27460.

Sanitary Law.

France's New Sanitary Law as Applied to Contractors and Builders. Comments on the hygienic precautions being enforced to prevent contagion, especially during the preparatory work for the coming exposition in Paris. 1400 w. Stone—May, 1899. No. 27734 C.

Specifications.

Specifications. F. W. Macey. Read before the British Architects' Association. Suggestions of particulars that should be given, and matters affecting the clearness, order, etc. Discussion. 1500 w. Builder—May 6, 1899. No. 27633 A.

CIVIL ENGINEERING

BRIDGES.

Address.

The Profession of Bridge Engineering. A lecture by J. S. Deans on the proper training of an engineer to become a specialist in structural metal work. 3000 w. Eng Rec—May 6, 1899. No. 27509.

Alexander III.

The Alexander III. Bridge, Paris; Construction and Erection of Arch Ribs. Abstract of description from the *Annales des Ponts et Chaussees*, with two-page plate. 1800 w. Eng News—May 25, 1899. No. 27755.

Atbara Bridge.

The Atbara River Bridge. Interesting data concerning the erection of this bridge on the line of railroad now building in the Soudan, and the quick fulfilment of the order by an American company. Ill. 1200 w. R R Gaz—May 26, 1899. No. 27768.

Bridge Architecture.

The Architecture of Bridges. Illustrated review of forms of bridge construction and embellishment. 2700 w. Bridges—April, 1899. Serial. 1st part. No. 27620 C.

The Architectural Element in Engineering Work. H. H. Statham. Abstract of paper read before the Royal Inst. of British Arch'ts. Thinks the viaduct is to the 19th century what the cathedral was to the 12th, 13th and 14th centuries. Discusses various types of bridge architecture. 2000 w. Archt, Lond—May 19, 1899. No. 27799 A.

The Architecture of Bridges, Parapets and Balustrades. Illustrated discussion of principles of design suited to various materials. 2000 w. Bridges—May, 1899. No. 27683 C.

Bridge Engineering.

Some Examples of Bridge Engineering. Illustrated descriptions of a number of engineering crimes in Iowa, with an editorial introduction on the subject. 3500 w. Eng Rec—May 6, 1899. No. 27504.

Buffalo, N. Y.

Street Bridges Over Railroad Tracks in Buffalo. Illustrated description of the important features of the largest bridges erected on the grade-crossing improvements of Buffalo. 2000 w. Eng Rec—May 13, 1899. No. 27578.

California.

Bridge Evolution as Relating to Southern California. C. E. Fowler. Part first is an introductory general review of progress in bridge design, especially of metal construction. Ill. 2000 w. Bridges—May, 1899. Serial. 1st part. No. 27682 C.

Culverts.

Culverts and Bridges. A. W. Campbell. Extract from a paper read before the Assn. of Ontario Land Surv's. Contrasts the practice in Canada with England in regard to the durability of structures; discusses the selection of a site, the size, materials, design, etc. 3000 w. Can Engr—May, 1899. No. 27556.

Designing.

Some Hints on Bridge Designing. Oscar Sanne. On the working out of details in a manner that will make a pleasing impression. 4000 w. Jour W Soc of Engs—April, 1899. No. 27691 D.

Drawbridge.

Draw-Span Stresses — Assumptions Made to Determine Them. Malverd A. Howe. A discussion of the question of making proper assumptions for the determination of stresses, and the methods in use at the present time. Ill. 3000 w. Bridges—April, 1899. No. 27619 C.

English Practice.

Recent English Practice in Bridges and Framed Structures. Alfred D. Ottewell. Illustrations with explanatory remarks. 2000 w. Bridges—May, 1899. No. 27681 C.

Estimating.

The Bridge Works' Estimating Department. E. M. Scofield. Suggests methods which have proved valuable in actual use. Ill. 2800 w. Bridges—April, 1899. No. 27621 C.

Highway.

The Greenpoint Avenue Bridge. Illustrated description of a low-level highway swing bridge for heavy city traffic. It is

about 200 feet in length, with a 20.5-foot roadway and two 5.75-foot sidewalks. 900 w. Eng Rec—May 27, 1899. No. 27785.

Niagara.

The New Bridge Over the Niagara River. General facts relating to the Atbara bridge so rapidly constructed, with detailed description of the Niagara bridge recently completed by the same company —the Pencoyd Iron Works, of Philadelphia. Ill. 3600 w. Engng—April 28, 1899. Serial 1st part. No. 27540 A.

Plate Girder.

Erection of a Plate Girder Span by Displacement. Illustrated account of the erection of a plate girder span by sliding it sidewise into the old position of a pony truss span, which was moved away at the same time. The new structure was used for train service while in transit. 900 w. Eng Rec—April 29, 1899. No. 27373.

CONSTRUCTION.

Beam.

The Determination of the Maximum Moment of a Simple Beam. (Bestimmung des Maximalmomentes Einfacher Trager.) Alexander Coulmas. A discussion by the graphical method, taking into account independent loads at various points. 2000 w. Zeitschr d Oesterr Ing u Arch Ver—April 14, 1899. No. 27828 B.

Bicycle Tracks.

Effect of Different Speeds and Radii of Curves Upon the Inclination of Bicycle Tracks. John C. Quade. Describes existing tracks and their construction, discusses the theory of bicycle-track construction, and considers the Garfield Park track in Chicago, and the Racine, Wis., track. 3000 w. Jour W Soc of Engs—April, 1899. No. 27690 D.

Eccentric Load.

Computation of a Column Subjected to an Eccentric Load. (Berechnung eines auf Excentrischen Druck Beanspruchten Stabes.) René Koechlin. With computations, based upon the elastic theory, for wrought iron, low steel, cast iron and wood. Two articles. 3000 w. Schweizerische Bauzeitung—May 6, 13, 1899. No. 27836 each B.

Foundations.

Pneumatic Caissons for Ordinary Foundations. A. W. Jones. Illustrates and describes the pneumatic work in connection with foundations of bridges. 5800 w. Bridges—April, 1899. No. 27618 C.

Groined Arch.

The Groined Arch as a Covering for Reservoirs and Sand Filters: Its Strength and Volume. Leonard Metcalf. The formulas given were deduced in connection with work at Somersworth, N. H. A sketch of the development of the groined arch is also given and a description of a method for computing the strength. Ill. 6500 w. Pro Am Soc of Civ Engs—May, 1899. No. 27773 E.

Pile Driving.

Pile Driving Formulas: Their Construction and Factors of Safety. Charles H. Haswell. Deductions and opinions given are the results of observations of a varied and extensive experience of pile-driving in every variety of soil. 3700 w. Pro Am Soc of Civ Engs—May, 1899. No. 27772 E.

Roads.

Country Road Construction in Ireland. Description of the methods followed in building roads over bogs and uplands where only local limestone is available on account of expense. 3100 w. Eng Rec—May 13, 1899. No. 27580.

Good Roads in New York State. Describes the methods of construction and gives an account of what has been done. 1300 w. Eng Rec—May 20, 1899. No. 27699.

Water as a Road Maker. William M. Bristol. Describes a case where water was used in road construction. Ill. 900 w. Min & Sci Pr—May 20, 1899. No. 27778.

Simplon Tunnel.

Notes on the Driving of Simplon Tunnel, Swiss Alps. Leopold Meyer. A general outline of the work, describing the surface installations, mode of work for the driving and power used, the ventilation and refrigerating plant. 2200 w. Can Min Rev—April 29, 1899. No. 27404 B.

Tunnel.

A Great Underground Railway Undertaking. Reviews the proposed work of tunneling under the East River and a portion of Brooklyn. 1800 w. Eng Rec—May 20, 1899. No. 27696.

The New Treptow-Stralau Tunnel Under the Spree. From *Das Buch fur Alle*. Brief illustrated description of an important engineering work. 600 w. Sci Am. Sup—May 20, 1899. No. 27645.

The Passy Tunnel (Le Tunnel de Passy). A description of the tunnel works on the new railway between Courcelles and Passy, with plate showing timbering and masonry, and a plan of the route. 2000 w. 1 plate. Revue Technique —May 10, 1899. No. 27812 D.

Tunneling.

The Shield Used in Constructing the Orleans Railway Tunnel, Paris. Brief abstract translation from *Le Génie Civil*. Gives illustrated description of the shield and the methods of construction employed. 1300 w. Eng News—May 4, 1899. No. 27467.

HYDRAULIC AND MARINE.

Canals.

Comparison Between Three Proposed Routes Across the Isthmus. Thomas Wright Hurst. Considers these different routes in regard to harbors, distance, level, climate, and troublesome rivers and lakes. 4800 w. Clay Rec—May 12, 1899. No. 27742.

New York State Canals. A statement of the five possible solutions under consideration by the committee appointed by the governor. 1500 w. Marine Rec—May 18, 1899. No. 27702.

Railway Competition with Canals in New York. Extracts from the circular letter issued by the commission appointed by the governor to investigate the canal question, with editorial comment on the problem. 3500 w. Eng News—May 11, 1899. No. 27596.

The Future of the New York State Canals. A statement of the relative merits of estimates for various improvements. 2000 w. Eng Rec—May 13, 1899. No. 27577.

The New Canal Plans. (Die Neue Kanal-Vorlage.) A special number devoted entirely to the Rhine-Elbe canal question, with a number of fine maps. 7500 w. 10 plates. Glückauf—April 8, 1899. No. 27859 G.

The Rhine-Elbe Canal. (Der Rhein-Elbe-Kanal.) A general account of the proposed waterway to connect the Elbe and the Rhine, with especial reference to the action of the German Government. 3000 w. Stahl und Eisen—April 15, 1899. No. 27852 D.

Dam.

Failure of Dam at Minneapolis Due to Previous Weakening Through Ice Pressure. James W. Rickey. An illustrated account of the failure of a portion of the main dam which controls the falls of the Mississippi River. 800 w. Eng News—May 11, 1899. No. 27598.

Failure of a Minneapolis Dam by Ice Pressure. Illustrated description of the overthrow of a stone wing dam after it was weakened by ice pressure. 1100 w. Eng Rec—May 13, 1899. No. 27579.

The Indian River Dam. George W. Rafter, Wallace Greenalch, and Robert E. Horton. Gives facts relating to the water storage in this Adirondack region, and a general description of the area; also an illustrated description of the construction of the dam. 9500 w. Eng News—May 18, 1899. No. 27668.

The Ochoa Dam. Illustrates and describes the nature of the structure which forms the key to the latest proposition for a Nicaragua Canal, with typical cross-sections of the canal. 700 w. Eng Rec—May 13, 1899. No. 27581.

Drainage Canal.

The Protest of St. Louis Against the Chicago Canal. Review of the report of a commission appointed to investigate the effect of the use of the Chicago canal on the interests of St. Louis. 1800 w. Eng Rec—April 29, 1899. No. 27371.

Drain Tile.

The History of Drain Tile and Its Uses. Thomas Townley. Deals principally with the use of tile in land drainage. 4000 w. Brick—May 1, 1800. No. 27485.

Dredging.

Experiments with the Kretz Jet Dredge. (Versuchsfahrten mit dem Kretzschen Spülbagger). With illustrations showing the combined action of the forcing and suction streams. 3500 w. Zeitschr d Ver Deutsher Ing—May 13, 1899. No. 27825 D.

Graving Dock.

Performances of Pumping Machinery: Clyde Trustees' No 3 Graving Dock. George H. Baxter. Extract from a paper read before the Inst. of Engs. and Shipbuliders in Scotland. Facts and analyses as to the performances of the machinery of one of the largest graving docks in the world. 900 w. Engr, Lond—April 28, 1899. No. 27537 A.

Hydrant Rentals.

New Judical Light on Hydrant Rentals. A Michigan decision, holding that in the absence of a contract, 8 per cent. on the cost of the necessary plant is the proper charge. 600 w. Eng Rec—May 20, 1899. No. 27695.

Lighthouse.

Lighthouse Illuminants. Lawrence Irwell. Discusses the use of oil, gas and electricity. 1800 w. Marine Rec—May 4, 1899. No. 27490.

Locks.

Hydraulic Lift Lock on the Trent Canal. Illustrated description of the balanced lift locks at Peterborough, Canada, which consist of two chambers 139 feet long, 33 feet wide, and 8 feet deep, raised and lowered through a distance of 65 feet by means of a hydraulic ram beneath each. 2400 w. Eng Rec—April 29, 1899. No. 27372.

River Improvement.

The Improvement of the Great Kanawha River, W. Va. Illustrates and describes the government improvements, which aim to furnish a depth of at least 6 feet of water over the entire length throughout the whole of the year. 2500 w. Eng Rec—May 27, 1899. Serial. 1st part. No. 27784.

Valves.

New Air-Relief and Pressure-Relief Valves. Illustrated description of new forms of valves for water mains. 900 w. Eng. Rec—April 29, 1899. No. 27374.

Waste.

Waste of Water at Erie, Pa. A statement of conditions existing in this city, showing that more water is wasted than used. Ill. 1400 w. Fire & Water—May 6, 1899. No. 27516.

Water Mains.

Moving Large Mains in Service. Illustrated description of the apparatus and methods employed in Philadelphia in moving mains up to 48 inches diameter. 1600 w. Eng Rec—April 29, 1899. No. 27375.

Water Meterage.

Meterage for Pittsburgh. A statement of conditions affecting the amount of water used and wasted in this city, and the recommendations of Mr. Allen Hazen in his report to the commission on filtration. 2300 w. Fire & Water—May 13, 1899. No. 27625.

Water Power.

Reform in Water-Power Rights in Austria. (Reform des Oesterreichischen Wasserrechtes.) Dr. Ernst Seidler. A discussion of the growing importance of water power and the legislation controlling its use in Austria. 3000 w. Oesterr Zeitschr f Berg u Huttenwesen—April 15, 1899. No. 27862 B.

Water Works.

A Large Artesian Well Plant at Camden, N. J. Describes a plant having a contract capacity of 20,000,000 gallons. 1200 w. Eng News—May 11, 1899. No. 27595.

How the Water-Supply of the City of Syracuse Is Kept from an Unpleasant Taste. W. R. Hill. Read before the American Water-Works Assn. Describes a simple operation by which the water has been kept free from vegetation. 2000 w. Fire & Water—May 20, 1899. No. 27693.

London Water Supply. Walter Hunter. Reviews the history of the supply, giving a descriptive summary of the works, discussing the future outlook. Discussion. 15500 w. Jour Soc of Arts—April 21, 1899. No. 27412 A.

Progress of the Metropolitan Water Works. Interesting information from the annual report of the Metropolitan Water Board of Massachusetts, covering the work done in 1898. 3200 w. Eng Rec—May 27, 1899. No. 27783.

Some Difficulties in Obtaining a Water Supply. Abstract of a paper by W. J. Milner, read at a meeting of the Am. Water Works Assn. On the difficulties met and overcome in supplying Birmingham, Ala., with water. Ill. 1600 w. Eng Rec—May 27, 1899. No. 27786.

The History of an Amateur Water-Works Plant. An account of the misfortunes of a plant erected without other engineering advice than that of the sales agent of a gas-motor firm. 1300 w. Eng Rec—May 13, 1899. No. 27582.

The New Water-Works of Camden, N. J. Illustrated description of a driven-well plant of about 16,000,000 gals. daily capacity, in which the details include special air-lift connections, pump well, submerged pipe laying and a concrete chimney cap. 300 w. Eng Rec—May 6, 1899. No. 27507.

MATERIALS.

Cement.

Fineness of Cement. Ira O. Baker. Gives reasons why cement should be well ground, data on fineness, and method of selecting the most economical cement. 1200 w. Br Build—April, 1899. No. 27359 C.

Report on the Constancy of Volume of Ten Portland Cements. (Bericht über die Raumbeständigkeit von Zehn Portland cementen.) M. Gary. A very full report by the Berlin Testing Laboratory and the German Society of Cement Manufacturers, upon the general properties of the cements, including the changes in volume under various conditions. An important document. 18000 w. 2 plates. Mill aus den Kgl Tech Versuchsanstalt—Part 1. 1899. No. 27858 G.

Cement Works.

The Vulcanite Portland Cement Company's Works. Frederick H. Lewis. Illustrates and describes a new plant for the manufacture of Portland cement, containing many new features for economical working, proved desirable by experience with an older plant at the same site, of which plans are also published. Particular attention is paid to the power plant details, which affect the cost of cement in a marked degree. 2000 w. Eng Rec—May 6, 1899. No. 27505.

Concrete Masonry.

See Railway Affairs, Permanent Way.

Inspection.

The Inspection of Iron and Steel, Its Development, What It Is, and Its Advantages. Frank C. Osborn. A brief description of the methods adopted by the Osborn Co., of Cleveland, O., illustrating the care taken in testing the materials. 3000 w. Bridges—May, 1899. Serial. 1st part. No. 27680 C.

MUNICIPAL.

Filtration.

A New Coagulant for Mechanical Filters. Describes the plant at Quincy, Ill., where the iron process is used with satisfactory results. 1000 w. Eng Rec— May, 27, 1899. No. 27789.

The Purification of Surface Water by Sand Filtration During Cholera Epidemic. (Grundsätze für die Reinigung von Obseflächenwasser durch Sandfiltration

zu Zeiten den Choleragefahr.) An abstract of the German government report with extracts showing the conditions to be maintained and the precautions necessary. 2500 w. Gesundheits-Ingenieur—April 15, 1899. No. 27856 B.

Cincinnati and Its Filtration Report. A statement of the conclusions reached as regards the English and American filtration systems. 450 w. Fire & Water—April 29, 1899. No. 27388.

The Cost of Filtration. Considers the estimates recently sent in by the filtration commission of Pittsburg, Pa., with a few words on the experience in Cincinnati. 1500 w. Fire & Water—April 29, 1899. No. 27387.

The Present Status of Water Filtration. Paper of George W. Fuller before the American Water Works Assn., reviewing the conditions found in many places in America, and their influence on purification work. 2000 w. Eng Rec—May 27, 1899. No. 27788.

Garbage Disposal.

Refuse Cremation at Edinburgh, Bradford and Oldham. An illustrated report by Lord Kelvin and Prof. A. Barr, on the construction and operation of the plants in the cities named. 4000 w. Eng Rec—May 6, 1899. No. 27510.

Mill-Drainage.

The Discharge of Hot Mill-Drainage into City Sewers. (Die Einführung Heisser Fabrikabwässer in Stadtische Kanäle.) Showing the effect of hot discharges in producing decomposition of sewage, and affecting public health. The safe limit of temperature is placed at 40° C. 2000 w. Gesundheits-Ingenieur—April 30, 1899. No. 27857 B.

Municipal Undertakings.

Municipal Notes. Illustrated description of various novel water, sewer and paving undertakings in a number of cities. 3500 w. Eng Rec—May 6, 1899. No. 27506.

Rain.

Tables of Excessive Precipitations of rain at Chicago, Ill., from 1889 to 1897, inclusive. Discussion on paper of Edwin Duryea, Jr. 20000 w. Jour W Soc of Engs—April, 1899. No. 27688 D.

Refuse.

The Utilization of City Refuse. W. F. Morse. Brief notes on the success attained in utilizing the heat from the burning of refuse. 1000 w. Munic Engng—May, 1899. No. 27379 C.

River Pollution.

Alleged River Pollution by the Bath Gas Company. A statement of a case in the English courts. Judgment not given. 5000 w. Gas Wld—May 13, 1899. No. 27712 A.

Russia.

Sanitation in Russia. Notes and observations on sanitary conditions in Russia. 4300 w. Am Arch—May 20, 1899. Serial. 1st part. No. 27692.

Sewage Regulator.

Sewage Regulator at Cambridge, Mass. Illustrated description of an apparatus used to regulate the flow of sewage into a main interceptor, and a device for automatically registering the state of the regulator. 600 w. Eng Rec—April 29, 1899. No. 27376.

Sewerage.

Perfect Sewerage and Perfect Health. Papers by W. R. Morrison, and by Graham M. Sinclair. Considers the essentials of a perfect system. 2800 w. San Plumb—May 1, 1899. No. 27487.

Portishead Sewerage Scheme. Detailed description of a system recently completed. The sewage is discharged into the Severn a third of a mile from the shore under conditions so favorable as to make it unobjectionable. 2800 w. San Rec—April 28, 1899. No. 27519 A.

Sewage Analysis and the Chemical Treatment of Sewage. Leonard P. Kinnicutt. Considers what sewage is and how an idea of its character is obtained, and the amount of purification accomplished by different methods of treatment. Gives special information concerning the chemical treatment. 5000 w. Eng News—May 11, 1899. No. 27594.

Sewage Disposal at Glasgow. James H. Fuertes. Illustrated description of works for treating 12,000,000 gals. daily by chemical precipitation and filtration through sand and coke. 2000 w. Eng Rec—May 20, 1899. No. 27697.

The Relation of Manufacturing Wastes to the Sewerage Problem. F. Herbert Snow. Abstract of a paper presented before the Civil Engs.' Club of Columbus, O. Gives a digest of experiments for purifying these wastes, made by the Mass. Bd. of Health, and other comments on the question of nuisance. 2000 w. Eng News—May 25, 1899. No. 27758.

The Shone Sewerage System at Karachi. Facts taken from a paper by James Strachan presented to the Institution of Civil Engs. Describes features of interest and gives the results of efficiency tests. 2000 w. Eng Rec—May 27, 1899. No. 27787.

Village Sewerage Schemes. Rev. Dr. Cox. Experiments in the rural district of Brixworth, Eng., giving attempts and failures. 2500 w. Jour San Inst—April, 1899. No. 27454 F.

Sewer Pipe.

Sewer Pipe: Its Manufacture. Anton Vogt. Part first considers the setting of the pipes in the kiln. 2400 w. Brick—

May 1, 1899. Serial. 1st part. No. 27-486.

Sewers.

Experience in Sewer Construction. L. M. Hastings. Notes experiences gained in the city of Cambridge, Mass., bearing on the difficulty of excavating and maintaining trenches, and expensive bracing and other work affecting the character and cost of the system. Ill. Discussion. 4500 w. Jour Assn of Engng Socs—March, 1899. No. 27382 C.

Maintenance of the System of Separate Sewers at Newton, Mass. Stephen Childs. Describes the system, the underdrains, flushing, ventilation, etc. Discussion. Ill. 7800 w. Jour Assn of Engng Socs—March, 1899. No. 27383 C.

Street-Cleaning.

Street Cleaning in San Francisco. A statement of the methods employed at the recommendation of the local Merchants' Assn. Hand-cleaning is preferred and the contractor is required to treat his men in a specified manner. 2000 w. Eng Rec—May 6, 1899. No. 27508.

Street Widening.

Proposed Widening of New York Streets. N. J. Vander Weyde. Map with explanation of needed changes. 450 w. Sci Am Sup—May 6, 1899. No. 27461.

Swimming Baths.

An Open-Air Swimming Bath-House. Illustrates and describes a Philadelphia bath having a capacity of about 100 bathers per hour, which has attracted considerable attention on account of its utility. 1600 w. Eng Rec—April 29, 1899. No. 27378.

MISCELLANY.

Drainage Plant.

Gasoline Engine Drainage Plants at Sixteenth Street Crossing, Chicago. Illustrates and describes the manner of solving a difficult problem in the disposal of surface water. 700 w. Ry & Engng Rev—May 13, 1899. No. 27624.

Engineering Societies.

The Austrian Society of Engineers and Architects. A brief review of the half-century's work of this great national organization. 1300 w. Eng Rec—May 6, 1899. No. 27503.

Niagara.

Niagara as an Industrial Center. The first of a series of articles descriptive of the topographical and engineering features. Map. 2300 w. Sci Am—May 27, 1899. Serial. 1st part. No. 27764.

Public Works.

National Public Works. George Y. Wisner. Read at a recent meeting of the Detroit Engng. Soc. Criticism of the policy of the United States which has kept the public funds under the control of the army engineer corps, with a history of the work. 3800 w. Marine Rev—May 11, 1899. No. 27589.

ELECTRICAL ENGINEERING

COMMUNICATION.

Auxiliary Circuits.

Auxiliary Circuits as Applied to the Commercial Telephone. H. P. Clausen. Illustrates and describes circuits and apparatus that may be applied with advantage, particularly to business house telephones. 2400 w. Elec Engng—May, 1899. No. 27706.

Cable Faults.

A Method of Detecting the Arrival of Faults on Board When Picking Up Submarine Cables. Walter J. Murphy. Illustrates and describes devices experimented with by the writer but not tested by actual practice to any great extent. 1000 w. Elect'n, Lond—April 28, 1899. No. 27525 A.

A New Method of Finding an Insulation Fault in a Submarine Cable While Raising for Repairs. E. Jona. Illustrates and describes a method that has given good results. 1600 w. Elect'n, Lond—April 28, 1899. No. 27526 A.

Cables.

See Measurement.

Charges.

The Exorbitant Charges for Telegrams to India and the Far East. Discusses the reasons for the unreasonable charges for telegrams between England and the Far East. 1200 w. Elec Rev, Lond—April 28, 1899. No. 27530 A.

Composite Circuit.

Simultaneous Telephony and Telegraphy. Charles Selden. Read before the Railway Telegraph Supts.' Assn. Reports experimental investigations of the method of Francois Van Rysselberghe. 2000 w. Elec Rev, N. Y.—May 24, 1899. No. 27767.

Fire Alarms.

The Evolution of the Fire Alarm Telegraph. P. R. Colpitt. Read before the Maritime Electrical Assn. at Halifax. Describes the system as it is to-day, and the various stages of improvement by which it reached the present perfection.

2500 w. Can Elec News—May, 1899. No. 27559.

Japan.

Electrical Notes from Japan. F. B. Crocker. Considers the telegraph, telephone, electric light, electric power, electric railway, electrical manufacturing and education. Part first considers the telegraph. 2500 w. Elec Wld & Elec Engr—May 20, 1899. Serial. 1st part. No. 27679.

Multiple System.

The Mercadier Multiple Telephone System. (Mercadier's Vielfach-Gegensprech system.) Describing improvements in the monotelephone system by means of which multiplex messages can be sent in opposite directions. Three articles. 7000 w. Elektrotech Zeitschr—April 27, May 4, 11, 1899. No. 27875 each B.

Space Telegraphy.

Aetheric Telegraphy. W. H. Preece. Showing that wireless telegraphy has passed the experimental stage and reached practical use. Discussion. 5000 w. Jour Soc of Arts—May 5, 1899. No. 27630 A.

Marconi System in Chicago. An illustrated account of the very successful test made in a city crowded with steel structures, electric circuits and electric apparatus. 1800 w. W Elect'n—April 29, 1899. No. 27400.

Prof. D. E. Hughes's Researches in Wireless Telegraphy. A letter concerning the priority of the invention of wireless signalling, giving an account of the writer's researches as early as 1879. 2400 w. Elect'n, Lond—May 5, 1899. No. 27634 A.

Radioconductors with Metallic Balls. (Radioconducteurs à Billes Metalliques.) E. Branly. A note to the French Academy describing M. Branly's early and more recent experiments with various forms of coherers. 1200 w. Comptes Rendus—May 1, 1899. No. 27845 D.

The South Foreland Wireless Telegraph Station. Illustrates and describes this station with some comments on Mr. Marconi's experiments. 2000 w. Elect'n, Lond—April 28, 1899. No. 27524 A.

The Theory of Wireless Telegraphy. M. Blondel, in the Comptes Rendus de l'Association Francais pour l'Advancement des Sciences. Attributes the principal effect to an oscillating system. 1100 w. Elec Rev, Lond—May 5, 1899. No. 27636 A.

Wireless Telegraphy. Reviews editorially what has been accomplished in this form of communication. 1200 w. Eng Rec—May 20, 1899. No. 27694.

Telediagraph.

Pictures by Telegraph. Describes the new system, called the telediagraph, for sending drawings by means of electricity. Ill. 1200 w. Elec Rev, N. Y.—May 3, 1899. No. 27488.

Telephone.

A Telephone System without Return Battery Current. (Fernsprechanlage ohne Rufstromquellen bei den Theilnehmerstellen.) G. Ritter. An illustrated account of an improved system in which batteries are required at the central station only. Three papers, 12,000 w. Elektrotech Zeitschr—April 6, 13, 20, 1899. No. 27-867 each B.

Reminiscences. F. A. Hamilton. Read before the Maritime Elec. Assn., at Halifax. On the uses and applications of the telephone, containing valuable suggestions. 1800 w. Can Elec News—May, 1899. No. 27560.

The Long Distance Transmission of Speech. J. H. Winfield. Read before the Maritime Elec. Assn., at Halifax. Notes some of the difficulties encountered in the design, construction and operation of long lines. 1600 w. Can Elec News—May, 1899. No. 27562.

Treasury Minute Upon the Proposals for the Development of the Telephone System in the United Kingdom. Full text, setting forth the proposals of the British Government with regard to the telephone service. 1200 w. Elect'n, Lond—May 19, 1899. No. 27797 A.

DISTRIBUTION.

Alternating Currents.

Alternating Electric Currents. Alton D. Adams. Illustrated explanation of alternating currents, showing that they are essentially different from the direct only in their periodic change of direction. 2700 w. Engr, U. S. A.—May 15, 1899. Serial. 1st part. No. 27627.

House Service.

House Service for Alternating Currents. (Ueber Hausanschlusse bei Wechselstromwerken.) R. Helm. An illustrated description of methods used in Germany for connecting residences and apartments with underground high-tension alternating conductors. 2500 w. Electrotech Zeitschr—April 6, 1899. No. 27865 B.

Mains.

Miscellaneous Notes on the Cheltenham Mains. Hamilton Kilgour. Read before the Northern Soc. of Elec. Engs. (England.) Describes the distributing works of electric supply at Cheltenham in part first. Ill. 2200 w. Elec Eng, Lond—May 12, 1899. Serial. 1st part. No. 27-713 A.

Polyphase Apparatus.

Polyphase Electrical Apparatus. Cecil P. Poole. Illustrates and describes various forms and their operation. 4400 w. Power—May, 1899. No. 27370.

Rectifier.

The Design of a Single-Phase Rectifier. J. C. Brocksmith. States the more important requisites for a rectifier, and gives working drawings and description for the construction. 2800 w. Am Elect'n —June, 1899. No. 27740.

Safety Appliances.

A New System of Safety Appliances. (Ueber ein Newes System von Sicherheitsmaterialien.) H. Dressler. Describing a variety of fuses designed to meet the requirements of the German Elektrotechnical Association. 3000 w. Elektrotech Zeitschr—May 4, 1899. No. 27878 B.

Stations.

Limited Electric Stations. Alton D. Adams. Considers methods of distribution and gives facts showing the growing preference for direct electric distribution over moderate areas. 2500 w. Am Elect'n —June, 1899. No. 27738.

Three-Phase.

Secondary Distributing Systems for Three-Phase Plants. Aug. J. Bowie, Jr. Briefly notes the six systems, with their advantages and disadvantages. 1700 w. Elec Wld & Elec Engr—April 29, 1899. No. 27362.

ELECTRO-CHEMISTRY.

Alkali Works.

The Electrolytic Alkali Works at Clavaux, France. John B. C. Kershaw. Describes the Hulin process and the works at Gavet Clavaux. Ill. 1700 w. Eng & Min Jour—April 29, 1899. No. 27367.

Chemistry.

The Electric Current in Chemistry. Part first reviews early discoveries, recalling the labors of eminent investigators, and the results won by them. 1500 w. Elec Rev, Lond—April 28, 1899. Serial. 1st part. No. 27529 A.

Electrical Energy.

Electrical Energy Produced Directly from Carbon. D. Tommasi. Describes the writer's battery and its theory. 1000 w. Elec Rev, Lond—May 12, 1899. No. 27715 A.

Electrolysis.

An Electrolytic Method of Obtaining the Halogen Salts of the Alkalies. (Ueber ein Elektrolytisches Verfahren zur Gewrunning der Chlor-Brom-und Iodsauren Salze der Alkalien.) Dr. E. Müller. Giving data as to solutions, electrodes, currents and operative details, as successfully employed by the author at the laboratory of the Dresden Polytechnic. 2500 w. Zeit f Elektrochem—April 13, 1899. No. 27879 G.

Osmotic Pressure, Dissociation, and Electrolysis. W. Bettel. A contribution to the discussion on Prof. von Oettingen's paper. 4500 w. Jour of Chem & Met Soc of S. Africa—March, 1899. No. 27665 E.

Ozone.

Experiments in the Sterilization of Water by Ozone. Emile Andreoli. The conditions under which the sterilization can be effected, and an account of experiments which demonstrated the powerful action of ozone as a germicide. 1600 w. Elec Rev, Lond—May 5, 1899. No. 27637 A.

ELECTRO-PHYSICS.

Conductivity.

The Conducting Analogy Between the Electric Arc and Certain Metallic Oxides. William Becket Burnie and Charles A. Lee. An account of experiments made to exhibit points of resemblance and dissimilarity between the arc and the oxides. 2000 w. Elect'n, Lond—May 12, 1899. No. 27717 A.

High Potential.

On the Decomposition of a High Potential Current. (Sur la Décomposition d'un Courant à Haut Potential.) H. Abraham. A communication to the French Academy recording the results of experiments with disruptive discharges produced by currents of high potential. 1500 w. Comptes Rendus—April 17, 1899. No. 27844 D.

Interrupter.

A Contribution to the Study of the Wehnelt Interrupter. (Contribution à l'Etude de l'Interrupteur Wehnelt.) H. Armagnat. An examination of the nature of the electrolytic action and the causes of the interruption and re-establishment of the circuit. 1000 w. Comptes Rendus—April 17, 1899. No. 27843 D.

A New Form of Wehnelt Interrupter. Elihu Thomson. Describes and illustrates a device embodying both anode and cathode, resembling somewhat a pencil. 300 w. Elec Wld & Elec Eng—May 6, 1899. No. 27493.

Improvements in the Wehnelt Interrupter. (Perfectionnements à l'Interrupteur Electrolytique de Wehnelt.) J. Carpenter. A brief note to the French Academy describing the effect of operating the Wehnelt interrupter at elevated temperatures. 800 w. Comptes Rendus—April 17, 1899. No. 27842 D.

Some Conditions of Action of the Wehnelt Interrupter. (Quelques Conditions de Fonctionnement de l'Interrupteur Electrolytique de M. Wehnelt.) Paul Bary. A communication to the French Academy giving the results of a number of experiments. 1000 w. Comptes Rendus—April 10, 1899. No. 27839 D.

Some Experiments with the Caldwell Interrupter. Charles T. Child. Illustrated description, with suggested theory. Also brief note from Harris Goldstein. 1000 w.

Elec Rec, N. Y.—May 10, 1899. No. 27-570.

The Liquid Interrupter. A discussion of this instrument by Elihu Thomson, E. W. Caldwell, and others. 1300 w. Elec Rev, N. Y.—May 17, 1899. No. 27655.

Magnetism.

Magnetism. J. A. Ewing. The "James Forrest" lecture, delivered at the Inst. of Civ. Engs., London. Part first is mostly a historical review of the developments and applications and early discoveries. 4600 w. Elect'n, Lond—April 28, 1899. Serial. 1st part. No. 27527 A.

Terrestrial Magnetism, and the Deviations of the Compasses of Iron Ships. John E. Davies. A review of investigations and progress in the study of terrestrial magnetism and its distribution, and of the deviations of a ship's compass. Ill. 5700 w. Wis Engr—May, 1899. No. 27-661 D.

Radiation.

Electrical Radiation. Arthur V. Abbott. Considers the general qualifications of transmitting and receiving apparatus, and the practical operation of signalling by electrical waves. Ill. 6800 w. Jour W Soc of Engs—April, 1899. No. 27689 D.

Electrical Radiation. J. E. Taylor. The article aims to throw more light on the mystery of wireless telegraphy. 2000 w. Elec Rev, Lond—May 12, 1899. Serial. 1st part. No. 27716 A.

Resistance.

The Variations in Electrical Resistance of Metals and Alloys from Torsion. (Sur la Variation de la Résistivite Electrique des Metaux et de leurs Alliages Due à la Torsion.) Coloman de Szily. A note to the French Academy, giving the results of experiments with various metals and alloys. 1200 w. Comptes Rendus—April 10, 1899. No. 27840 D.

Waves.

Propagation of Long Electrical Waves. M. I. Pupin. Describes an experimental method of investigating the propagation of long electrical waves and discusses the mathematical theory bearing upon the same. 9900 w. Trans Am Inst of Elec Engs—March, 1899. No. 27458 D.

GENERATING STATIONS.

Bootle, Eng.

Bootle Electricity Works. Illustrated detailed description and historical account. 1300 w. Elec Eng, Lond—April 21 and 28, 1899. Serial. 2 parts. No. 27415 each A.

Boston, Mass.

Central Station of the Boston Electric Light Company. Illustrates and describes this station as a solution of the problem of alternating current and series arc generation and distribution on a large scale. 3000 w. Am Elect'n—June, 1899. No. 27739.

Charges.

Notes on Methods of Charging for Electric Service. (Bemerkungen zur Tariffrage bei Elecktricitätswerken.) K. Wilkens. A development of practical formulas by which the prices to be charged to customers may be derived from the cost data of the station. 2500 w. Elektrotech Zeitschr—April 13, 1899. No. 27869 B.

Cologne.

Statistics of the Electric Plant at Cologne. (Stadtisches Elektricitätswerk zu Koln.) A full report of the work of the Cologne station, both for light and power, fully tabulated, in comparison with previous years. 2500 w. Elektrotech Zeitschr—April 6, 1899. No. 27868 B.

Dynamos.

Bipolar and Multipolar Construction. Alton D. Adams. Aims to point out certain features in which bipolar are inferior to multipolar dynamos as at present made. 1400 w. Elec Wld & Elec Engr—April 29, 1899. No. 27366.

Mechanical Stresses on Dynamo Coils. P. M. Heldt. An explanation of the phenomenon observed, with proof of the subject in general and investigation of a few special cases. Ill. 2200 w. Elec Wld & Elec Engr—May 27, 1899. No. 27780.

English Stations.

Some English Central Stations. Illustrates and describes features of central station engineering differing from American practice. 3800 w. Am Elect'n—June, 1899. No. 27735.

Field Magnets.

On the Dimensioning of Field Magnets. George T. Hanchett. Enumerates the requirements and conditions in designing field magnets, and explains a method for determining with accuracy the length for the magnetic circuit. 1000 w. Elec Wld & Elec Engr—April 29, 1899. No. 27-364.

Hammersmith, Eng.

Hammersmith Electricity Works Extension. An illustrated account of the extension of these supply works. 2800 w. Elec Rev, Lond—April 21, 1899. No. 27-418 A.

Interrupter.

Pneumatic Interrupter for Accumulator Conductors. (Pneumatischer Stromunterbrecher für Akkumulatoren-Ladestromkreise.) Describing the Petersen apparatus, in which the pneumatic pressure caused by the accumulation of gas in a closed cell interrupts the connection when the battery is charged. 1000 w. Elektrotech Zeitschr—May 4, 1899. No. 27877 B.

Municipal Plant.

Estimate for a 1,537-Light Municipal Electric-Lighting Plant for San Francisco, Cal. Abstract of a report submitted to the Mayor and Board of Supervisors of the city, by A. W. Hunt, the consulting engineer. 800 w. Eng. News—May 25, 1899. No. 27757.

The Municipal Electric Light and Water Plant of Madison, N. J. Describes and illustrates a small attractive municipal station. 1300 w. Am Elect'n—June, 1899. No. 27736.

Paderno.

The Electric Power Plant at Paderno, on the Adda. (Die Elektrische Kraftüebertragungs-Anlage Paderno d'Adda-Mailand.) An illustrated account of the Paderno power plant by which 13,000 h.p. is taken from the Adda for transmission to Milan, 21 miles distant. Serial. 1st part. 2500 w. Schweizerische Bauzeitung —May 13, 1899. No. 27837 B.

Portland, Me.

Power Transmission Plant in the Maine Woods. Illustrates and describes the electric power transmission plant of the Cumberland Illuminating Co., of Portland, Me. 2000 w. Elec Wld & Elec Engr—April 29, 1899. No. 27361.

Private Station.

A Private Central Station. Illustrates and describes the monocyclic isolated plant of the Frank Jones Electric Light Station of Portsmouth, N. H. 1700 w. Am Elect'n—May, 1899. No. 27481.

Transformers.

The Zipernowski-Déri-Blathy Transformer Distribution Patents. Text of two patent specifications that have recently expired, which, it is claimed cover the general principles governing practical transformer construction and alternate-current distribution. 2400 w. Elect'n, Lond—April 21, 1899. No. 27419 A.

Transformer Core Losses. W. Elwell Goldsborough. On the improvements in transformers and the effect of the apparatus on the earning capacity of plants, showing the gain that follows the substitution of modern transformers for the antiquated types. 3300 w. Elec Wld & Elec Engr—May 20, 1899. No. 27678.

Transformer Testing for Central Stations. J. H. Perkins. The paper points out the extensions and changes which practice has shown to be desirable in the methods used. 2500 w. Wis Engr—May, 1899. No. 27657 D.

HEATING AND WELDING.

Thawing.

Thawing Frozen Water Pipes by Electricity. Abstract of a paper by John B. Heim, read at meeting of the American Water Works Assn. 1700 w. Eng Rec —May 20, 1899. No. 27698.

LIGHTING.

Arc Lamps.

The Arc Lamp Department of the Central Station Business. H. W. Hillman. Suggestions as to the organization and conduct of such a department. 5000 w. Elec Rev, N. Y.—May 3, 1899. No. 27489.

Triple Connection of Arc Lamps. (Ueber die Dreierschaltung von Bogenlampen.) W. Wedding. A record of electrical and photometric measurements made upon the Korting and Mathiesen arc lamps connected three in series. 2500 w. Elektrotech Zeitschr—April 13, 1899. No. 27870 B.

Candle Power.

The Candle Power of Arc and Incandescent Lamps. Wilbur M. Stine. Considers the leading standards of illuminating power proposed. 1400 w. Am Elect'n—June, 1899. No. 27737.

Light Baths.

Electric Light Baths. Brief account of the appliances used in giving these baths, and their advantages. 800 w. Elect'n, Lond—May 5, 1899. No. 27635 A.

Nernst Lamp.

The American Nernst Lamp Patent. An account of the principles of the Nernst lamp as contained in the American patent. 1300 w. Elec Wld & Elec Engr—April 29, 1899. No. 27360.

Theatre Lighting.

Electric Lighting of Covent Garden Theatre. Illustrated detailed description of the alterations in lighting which are being made, changing from an antiquated gas service to electric lighting. 2400 w. Elec Eng, Lond—May 5, 1899. No. 27638 A.

MEASUREMENT.

Cables.

Capacity Measurements of Long Submarine Cables. J. Elton Young. Read before the Brit. Inst. of Elec. Engs. A critical comparison of Gott's, Thompson's and Muirhead's methods. 2000 w. Ind & Ir—May 5, 1899. Serial. 1st part. No. 27601 A.

Capacities.

Relative Dynamo and Motor Capacities. Alton D. Adams. On the method of determining the capacity of a given dynamo when used as a motor and vice versa. 1500 w. W Elect'n—April 29, 1899. No. 27401.

Dynamo Testing.

A Simple Method of Testing Dynamos. (Ueber eine Einfache Methode zur Prü-

fung von Dynamomaschinen.) C. Liebenow. Advocating the periodical testing of dynamos in the same systematic manner as is applied to engines and boilers and outlining a system. 3000 w. Elektrotech Zeitschr—April 13, 1899. No. 27871 B.

Dynamo Tests for Efficiency. Arthur L. Rice. An explanation of what efficiency is, and the best method of computing it. 2400 w. Engr, U. S. A.—May 1, 1899. No. 27455.

Meters.

Electric Meters. R. T. MacKeen. Read before the Maritime Elec. Assn., at Halifax. On the service and care of meters, the need of inspection, etc. 2000 w. Can Elec News—May, 1899. No. 27561.

Oscillograph.

Recent Experiments with the Oscillograph. Andre Blondel. Abstract translation from *L'Industrie Electrique*. Reports recent progress in the construction of the two principal types of this apparatus. 2500 w. Elec Rev, N. Y.—May 24, 1899. No. 27766.

Phase Angles.

Phase Angle Measurements. Edwin Place. A report of the writer's investigations in this field, and the conclusions reached. Ill. 3300 w. Elec Wld & Elec Engr—May 13, 1899. No. 27572.

Pressure.

An Accurate Method and Apparatus for Measurement of Pressure in Feed Wires Ueber ein Verfahren und einen Apparat zur Fehlerfreien Messung der Speisepunktsepannungen in Leitungsnetzen). Dr. J. Teichmuller. A mathematical discussion of the causes of error, and a description of a voltmeter with adjustable resistance to enable accurate measurements to be made. 2500 w. Elektrotech Zeitschr—April 6, 1899. No. 27864 B.

POWER APPLICATIONS.

Efficiency.

Efficiency of Small Motors. Alton D. Adams. Considers the character and location of losses in motors under the heads of loss in armature and magnet winding, losses in iron cores and pole's, and losses by friction of bearings, commutator and air. 1300 w. Am Elec—May, 1899. No. 27483.

Locomotives.

Electric Locomotives. Abstract of a paper by Mr. McMahon read before the Inst. of Elec. Engs (England). The paper was based on figures obtained over a period of two years of daily working on the City and South London Ry. 2800 w. Elec Rev, Lond—May 12, 1899. Serial. 1st part. No. 27714 A.

Mine Plant.

Electric Power Transmission and Lighting Plant at the "Hollertszug" Mine. (Elektrische Kaftubertragungs und Beleuchtungs-anlage der Eisenerzgrube "Hollertszug".) An excellent example of the use of electricity in mine hoisting, pumping, air-compressing and lighting. 2000 w. Gluckauf—April 29, 1899. No. 27860 B.

The Application of Electricity for Work in Collieries. Clifford R. Buck. Brief account of current practice in the use of electric power for colliery installations. Ill. 7000 w. Sch of Mines Quar—April, 1899. No. 27453 D.

Motors.

The Theory of Asynchronous Motors. (Zur Theorie der Asynchronmotoren.) Julius Heubach. A general graphical study of single and polyphase motors, with diagrams and tables of coefficients for practical use. Two articles, 6000 w. Elektrotech Zeitschr—April 27, May 4, 1899. No. 27874 each B.

Propulsion.

Electric Power for Marine Propulsion. Charles T. Child. A discussion of the advantages of electric propulsion for special conditions, such as ferryboats, torpedo boats, etc., where intermittent service or silence and secrecy render steam unsatisfactory. 2500 w. Engineering Magazine—June, 1899. No. 27899 B.

TRANSMISSION.

Milan-Paderno.

The Power Transmission and Central Station Plants of the "Societa Generale Italiana Edison di Elettricita" at Milan. Illustrated description of one of the finest and largest installations in Europe. 1800 w. Elec Rev, N. Y.—May 10, 1899. No. 27569.

MISCELLANY.

Connecting Tool.

Connecting Tool for High Tension Conductors. (Ableitungs Schraubklemme für Hochspannungs leitungen.) P. von Kowaleff. An ingenious tool by use of which a wire may be attached to a high-tension conductor without risk to the operator. 800 w. Elektrotech Zeitschr—April 6, 1899. No. 27866 B.

Torpedo Steering.

Torpedo Steering by Ether Waves. Illustrates and describes an invention by Walter Jamieson and John Trotter for the wireless control of torpedoes. 1700 w. Elect'n. Lond—May 19, 1899. No. 27796 A.

Volta.

The Centenary of Volta's Discovery of the Electric Battery. A brief review of Volta and his time, with illustrations. 2200 w. Elec Wld & Elec Engr—May 13, 1899. No. 27571.

GAS ENGINEERING

Acetylene.

Acetylene Gas Accidents. John B. C. Kershaw. A summary of accidents that have come under the writer's notice during the last two years. 1000 w. Elec Rev, Lond—April 28, 1899. No. 27531 A.

Acetylene Gas as a Mine Illuminant. A. Holland. Abstract of an address before the Can. Min. Inst. Reports the use in the Grand Calumet Silver Lead Mine, and states its advantages as a mine illuminant. 1300 w. Ir & Coal Trds Rev—April 28, 1899. No. 27548 A.

Address.

Inaugural Address Before the Institution of Gas Engineers. F. D. Marshall. The address discusses English and Continental methods of gas production, and subjects of interest to gas engineers. 7300 w. Jour Gas Lgt—May 2, 1899. No. 27566 A.

Ammonia.

On the Methods Employed in the Analysis of Commercial Ammonia. A. Lunge and W. Hefter. Reviews methods recently published on this subject. 900 w. Am Gas Lgt Jour—May 8, 1899. No. 27513.

The Determination of Ammonia in Gas Liquor: A Simple Method. Dr. Lubberger. Summary of an article in the *Journal für Gasbeleuchtung*. Describes a method giving data much nearer analytical results than are those obtained by Knubbauch's method. 900 w. Gas Wld—May 20, 1899. No. 27794 A.

Analysis.

Improvements in the Analysis of Gas. On the method adopted by Dr. Otto Pfeiffer, of Magdeburg, and the faults of methods now in use. Ill. 2400 w. Gas Wld—April 29, 1899. No. 27522 A.

Calcium Carbide.

On the Crushing of Raw Materials for the Manufacture of Calcium Carbide. Abstract from the *Zeitschrift für Electrochemie*. Practice has shown that comparatively coarse crushing is better than pulverizing, and this has caused a change in the machinery used, and the manner shown to be most advantageous is given. 1500 w. Elect'n, Lond—May 19, 1899. No. 27798 A.

Carbide Patent.

The Nullification of the Bullier Carbide Patent in Germany. (Zur Nichtigkeitserklärung des D. R. P.Nr. 77168 Bullier Verfahren- zur Darstellung von Er dalkalicarbiden.) Dr. W. Borchers. A review of the decision, with the text of the patent and references to anticipations of the recent carbide patents. Two articles. 7500 w. Zeitschr f Elktrochemie—April 20, May 18, 1899. No. 27880 each G.

Carbonic Oxide.

Water Gas and Other Gases Containing a Large Proportion of Carbonic Oxide. A few of the important facts and theories embodied in the recent report of the committee appointed by the Home Secretary to inquire into their manufacture and use. 4000 w. Prac Engr—May 12, 1899. No. 27711 A.

Carbonization.

A Rotatory Retort and Water Gas Generator. Specifications of an apparatus for producing illuminating gas by the distillation of coal, shale, or carbonaceous tar. Ill. 2000 w. Gas Wld—April 29, 1899. No. 27523A.

Coal Tar.

Notes on Coal Tar and the Preparation of Its Products. Ernest F. Hooper. Read before the North of England Gas Managers' Assn. Considers coal tar and its constituents, giving a brief historical summary, and how the products are prepared. 4500 w. Jour Gas Lgt—May 2, 1899. No. 27568 A.

Coke Handling.

Coke Handling Plant. T. Holgate. Read before the British Inst. of Gas Engs. A report of the officers' experience, and information gathered in connection with the introduction of a coke handling plant at Halifax. Detailed description of the plant and appliances. Discussion. Ill. 15400 w. Gas Wld—May 6, 1899. No. 27647 A.

Combustion.

The Products of Combustion of Illuminating Gas. Digest of an interesting paper by Prof. Gréhant presented to the Societe d'Encouragement pour l'Industrie Nationale. Gives methods used by the writer in researches. Various types of gas burners were examined. 2700 w. Jour Gas Lgt—April 25, 1899. No. 27479 A.

Distribution.

A Notable Gas Engineering Feat in the City. Describes a unique piece of work made necessary by the construction of the Central London Railway. Ill. 1800 w. Jour Gas Lgt—May 16, 1899. No. 27759 A.

A Note on Distribution. C. C. Carpenter. Read before the British Inst. of Gas Engs. Gives a description of the method adopted by the South Metropolitan Co. for getting the benefit of high pressure in the initial mains. Discussion. 3000 w. Gas Wld—May 6 ,1899. No. 27649 A.

Gasholders.

Large Gasholders in England. Norton H. Humphreys. Considers gasholders about 230 feet in diameter and 150 feet high. 2000 w. Am Gas Lgt Jour—May 22, 1899. Serial. 1st part. No. 27703.

Wind Pressure on Buildings and Other Structures. J. O. V. Irminger. Read before the British Inst. of Gas Engs. An interesting paper, showing the bearing of the subject on the construction of gasholders. Ill. 5500 w. Gas Wld—May 6, 1899. No. 27651 A.

History.

Notes Upon the Early History of Gas Manufacture. H. C. Slaney. Read bebefore the Brooklyn Engs.' Club. Reviews the history of this industry, its works and accessories. Ill. 3500 w. Pro Age—May 15, 1899. No. 27622.

Hydraulic Mains.

The Hydraulic Main and Its Fittings. L. A. Guyatt. Read before the Eastern Gas Mgrs.' Ass'n, England. Illustrates and describes a form of tar-overflow used in the Vauxhall and Bankside works of the South Metropolitan Gas Co. 1700 w. Gas Engs' Mag—May 10, 1899. No. 27793 A.

Mains.

Some Special Features in the Connecting Mains of a Provincial Gas Company's Stations. W. Doig Gibb. Read before the North of England Gas Managers' Assn. Notes refer to the Newcastle works, Gateshead works, the new works, and the North of Tyne governor-house in England. Ill. Discussion. 8300 w. Jour Gas Lgt—May 2, 1899. No. 27567 A.

Mantles.

Incandescent Mantles. Vivian B. Lewes. Read before the British Inst. of Gas Engs. Reviews the discovery of the principle of the Welsbach mantle, the improvements, the theories advanced to explain efforts, etc. 7800 w. Gas Wld—May 6, 1899. 27652 A.

Nitrogen.

The Direct Estimation of Nitrogen in Gases. J. Kent Smith. Read before the Liverpool Section of the Society of Chemical Industry. Describes a method for the direct estimation of nitrogen in illuminating and other gases without the aid of gas analysis apparatus. 1200 w. Jour Gas Lgt—April 25, 1899. No. 27480 A.

Oil Gas.

The Oil-Gas Plant at Hutteldorf-Hacking. (Die Oelgas-Anstalt in Hütteldorf-Hacking.) Franz Grobben. A plant for the manufacture of oil-gas for use on the Vienna local railway. Both the generating and compressing apparatus are described. 2000 w. Zeitschr d Oesterr Ing M Arch Ver—April 21, 1899. No. 27829 B.

Photometers.

How to Make and Use a Photometer. Arthur J. Rowland. Gives directions for the construction and use. Ill. 3700 w. Am Elect'n—May, 1899. No. 27484.

Pipes.

Determining the Size of Gas Pipes. W. Graffton. Directions for determining the size of pipes needed to supply a certain number of lights. 700 w. Am Gas Lgt Jour—May 8, 1899. No. 27512.

Some Notes on Purification. A. L. Clarke. Read before the Eastern Cos. Gas Managers' Assn. Notes on hydraulic and foul mains, washing, and dry purification, with discussion. 4400 w. Gas Wld—April 22, 1899. No. 27420 A.

Retorts.

Notes on Modern Systems of Retort Heating. G. P. Lewis. Read before the British Inst. of Gas Engs. Deals with the principles of recuperative firing, giving a detailed comparative statement of the points at present under discussion in reference to the use of gaseous fuel in retort settings. Ill. 7500 w. Gas Wld—May 6, 1899. No. 27648 A.

Water Gas.

The Practical Working of Carburetted water Gas. Charles F. Botley. Read before the British Inst. of Gas Engs. A practical account of the plant which has been put up at Hastings, the conditions and results of the working. Discussion. 15500 w. Gas Wld—May 6, 1899. No. 27650 A.

MARINE AND NAVAL ENGINEERING

Battleships.

The Old Line of Battleship "Pennsylvania." Illustrated description of this old battleship, launched in 1837, and of Nelson's flagship, the "Victory." 1600 w. Sci Am—May 27, 1899. No. 27765.

Boiler Explosion.

See Mechanical Engineering, Steam Engineering.

Cruisers.

Cross-Section of the Diadem. Cross-section of a vessel of the protected-cruiser

type, with description. 1700 w. Engr, London—April 21, 1899. No. 27423 A.

Trials and Experiments Made on H. M. S. Argonaut. John Durston. Read before the Brit. Inst. of Naval Archts. An account of the results of the contract, trials and of experiments made. 3600 w. Trans of Brit Inst of Naval Archts—March, 1899. No. 27600 E.

Destroyers.

Torpedo-Boat Destroyers for Sea Service. James Howden. Read before the Brit. Inst. of Naval Archts. Illustrates and describes designs for making these vessels more effective as sea boats. 4000 w. Trans of Brit Inst of Naval Archts—March, 1899. No. 27599 E.

Gun Fire.

Effect of the Gun Fire of the United States Vessels in the Battle of Manila Bay. John M. Ellicott. Report by the Intelligence Office of the U. S. S. Baltimore, which took part in the action. Ill. 4200 w. Naut Gaz—April 27, 1899. No. 27355.

Ice Breaker.

The Ice Breaking Boat "Ermack." (Le Vapeur Brise-Glace "Ermack.") A general description of the new Russian ice breaker, with plan and sections, and an account of the successful opening of the harbor of Cronstadt. 2000 w. Le Yacht—April 15, 1899. No. 27863 B.

Marine Engines.

Engines Afloat. Part first considers bilge pumps and the means of locating and remedying difficulties. 1800 w. Prac Engr—April 21, 1899. Serial. 1st part. No. 27417 A.

Monitor.

The Old Type of Monitor. William H. Wiley. Remarks of Admiral Bunce, with description of the engines. Ill. 1700 w. Ir Age—May 18, 1899. No. 27654.

Motor Boat.

Motor Boat for Sea Service. Illustrates and describes a sea-going alco-vapor motor boat, designed for short cruises on the exposed coast of Maine and Massachusetts. 350 w. Marine Engng—May, 1899. No. 27474 C.

Repair-Ship.

The Work of the Naval Repair-ship Vulcan. Gardiner C. Sims and W. S. Aldrich. Giving an authoritative account of the equipment and work of the floating machine-shop of the American navy. 6000 w. Engineering Magazine—June, 1899. No. 27891 B.

River Boats.

Our Western Rivers. Part first considers the Mississippi and its tributaries, the commerce and types of craft navigating these streams. Ill. 1800 w. Naut Gaz—May 11, 1899. Serial. 1st part. No. 27588.

Shafting.

Notes on the Manufacture of Shafting for Screw Steamers, with Some Causes of Defects and Failures. E. C. Chaston. Abstract of paper read before the N. E. Coast Inst. of Engs. and Shipbuilders. Aims to prove that about half the defects and failures are due to preventable causes. 1200 w. Mech Wld—April 21, 1899. Serial. 1st part. No. 27413 A.

Shipbuilding.

The Connection Between Mechanical Engineering and Modern Shipbuilding. William H. White. Presidential address before the Inst. of Mech. Engs. Aims to indicate the directions in which shipbuilding and the working of ships have been influenced by mechanical engineering. 2500 w. Engng—April 28, 1899. Serial. 1st part. No. 27541 A.

Steamer.

T.-S. S. "Moskva," for the Russian Volunteer Fleet. Profile and deck plans with description of this twin-screw mail and passenger steamer. 600 w. Engng—May 12, 1899. No. 27724 A.

Steel Construction.

The Arthur Sewall, an American Shipentine Built of American Steel. Illustrated detailed description with principal dimensions. 1500 w. Marine Engng—May, 1899. No. 27473 C.

Trial Tank.

Influence of the Walls of Trial Tanks Upon the Indications of Current Meters (Einfluss der Wandungen von Versuchscanälen auf die Umlanfwerte Hydrometrische Flügel.) A report of the government hydrographic bureau, showing the precautions necessary for the accurate calibration of current meters. An important contribution to hydrodynamics. 10,000 w. 2 plates. Oestess Monatschr f d Oeffent Baudienst—May, 1899. No. 27827 D.

Water Tube.

Babcock & Wilcox Water-Tube Boilers in H. M. S. "Sheldrake." Particulars regarding the installation and tests. Ill. 2400 w. Steamship—May, 1899. No. 27521 A.

Yacht.

The New Royal Yacht. An illustrated description of Her Majesty's New Yacht—Victoria and Albert—with an interesting account of the launching. 4000 w. Engng—May 12, 1899. No. 27723 A.

Yarrow Boiler.

A Tale of a Yarrow Boiler. Illustrated description of the condition of a boiler on a minor vessel of the American navy, after a service of some months on the Cuban blockade. It had been in use thirteen months. 1400 w. Locomotive—March, 1899. No. 27550.

MECHANICAL ENGINEERING

AUTOMOBILISM.

Advantages.

Some Sanitary and Allied Advantages Attending the Introduction and Use of Motor Vehicles. E. Shrapnell Smith. Full paper as read before the Municipal and County Engs. Deals with improvements in sanitary conditions and reduction of cost. 1200 w. Jour San Inst—April, 1899. No. 27468 F.

Early Designs.

Some Early Forms of the Automobile. Illustrated historical account of early mechanical road carriages, dating back to 1763. 1300 w. Sci Am—May 13, 1899. No. 27590.

Electric Vehicles.

American Types of Electric Motor Vehicles. Thomas B. Booth. Part first gives illustrated descriptions of the Columbia automobiles, with comments on the development and progress of this industry. 5000 w. Elec Wld & Elec Eng—May 6, 1899. Serial. 1st part. No. 27492.

Hub.

A Rubber Cushioned Hub. Illustrated description of an invention for reducing the vibration of vechicles, adapted for motor vehicles and cycles. 600 w. Engr. Lond—April 28, 1899. No. 27538 A.

Motor Car.

A Gasoline Motor Car. Illustrated description of a car built by the Jewett Car Co., of Jewett, O. 1000 w. R R Gaz—May 5, 1899. No. 27495.

Operating Cost.

The Cost of Working an Automobile. Dr. Calbet, in *La France Automobile.* Statement of expenses for the year 1898, with comments. 1000 w. Automotor—May 15, 1899. No. 27744 A.

Paris Cabs.

The Central Station of the Electric Cab System of Paris. (Station Centrale de Fiacres Electriques de la Compagnie Générale des Voitures à Paris.) E. Campagne. Giving views of buildings, cabs, generating plant, accumulator room, etc., and a general account of the work of the company. 3500 w. 1 plate. Génie Civil—April 15, 1899. No. 27800 D.

Petroleum Vehicles.

Petroleum Motor Vehicles. James D. Roots. Excerpt of paper read before the Soc. of Engs. Gives illustrated descriptions of vehicles constructed since 1885, and the progress made. 7000 w. Automotor—May 15, 1899. No. 27745 A.

Regulators.

Speed Regulators for Petroleum Engines. Anthony G. New. Considers the method of regulating the speed of the engine by varying the time of ignition, and compares in with the tube-ignition engine. fitted with hit-and-miss governor. 1000 w. Automotor—May 15, 1899. No. 27747 A.

Steam Bicycle.

S. H. Roper's Steam Bicycle. R. I. Clegg. Illustrated description, with an account of the work of the inventor. 1500 w. Am Mach—May 18, 1899. No. 27640.

Wheels.

Stresses in Driving Wheels. H. E. Wimperis. Wooden wheels are mainly considered. 1000 w. Automotor—May 15, 1899. No. 27746 A.

HYDRAULICS.

Power Distribution.

Hydraulic Transmission and Distribution of Power. E. B. Ellington. The concluding paper is devoted to the practical questions connected with the delivery and utilization of hydraulic power, including motors and tools operated directly by hydraulic pressure. 3500 w. Engineering Magazine—June, 1899. No. 27893 B.

Turbine.

The Efficiency of the Screw Turbine. (Die Nutzleistung der Schraubenturbine.) M. Möller. A mathematical discussion showing the conditions under which the highest efficiency may be attained. 2000 w. Zeitschr d Ver Deutscher Ing—May 13, 1899. No. 27824 D.

Water Wheels.

Water Wheels, Ancient and Modern. Illustrates and describes primitive pieces of apparatus for utilizing the power of water. Part first deals with the ancient methods. 2000 w. Fire & Water—May 13, 1899. Serial. 1st part. No. 27626.

MACHINE WORKS AND FOUNDRIES.

Accidents.

The Prevention of Accidents in Industrial Concerns. L. Charles Wallach. Considers the importance of giving attention to this subject, the primary causes of accidents, safety guards and appliances, etc. 3500 w. Mech Wld—May 12, 1899. No. 27707 A.

Air Furnaces.

Reverberatory Air Furnaces; Malleable Practice. E. C. Wheeler. Considers these furnaces and claims that automatic stok-

ing will solve the combustion question and cure all existing defects. 3500 w. Foundry —May, 1899. No. 27704.

Bar Iron.

Suggested Improvements in the Manufacture of Bar Iron. Samuel Peters. Read before the Engs. Soc. of W. Penna. Brief description of a method which the writer thinks will give desirable results. 2700 w. Am. Mfr & Ir Wld—May 26, 1899. No. 27781.

Blacksmith Shops.

Modern Blacksmith Shops. S. H. Stupakoff. An account of the progress and changes, the tools used, etc. 2500 w. Ir Trd Rev—May 11, 1899. No. 27591.

Brass.

Light Brass Founding. C. Vickers. Suggestions for this class of work. 1600 w. Am Mach—May 11, 1899. No. 27565.

Brasses.

Some Points About Making Car Brasses. Views of Mr. James Swan on the subject of the making and care of journal brasses. 900 w. Ry Mas Mech—May, 1899. No. 27553 A.

Bridge Shops.

Notable New Bridge-Shop Machines. Illustrated description of modern tools and the power application used. 2800 w. Bridges—May, 1899. No. 27684 C.

Bronze.

Phosphor Bronze. A Description of Its Characteristics and Methods of Manufacture. L. L. Smith. Deals with the composition and specifications, action of phosphorus, foundry treatment, etc. 1900 w. Am Eng & R R Jour—May, 1899. No. 27394 C.

Burnishing.

Burnished Finish for Journals and Plain Surfaces. On the advantages of the roller finish and the practice of various roads. Ill. 1800 w. Am Eng & R R Jour—May, 1899. No. 27397 C.

Cast Iron.

Theories and Facts Relating to Cast-Iron and Steel. Bertrand S. Summers. Abstract of a paper read before the British Iron and Steel Inst. Discusses the physics of cast-iron and steel, and the possibly important action of Prof. Ledebur's graphitic temper-carbon . 3200 w. Ir & Coal Trds Rev—May 12, 1899. No. 27719 A.

Charges.

Shop and General Establishment Charges in Engineering Works and Their Relation to Cost and Estimates. William Edward Cowens. Read before the Northeast Coast Inst. of Engs. and Shipbuilders. A suggestive paper written from the works manager's standpoint. 2800 w. Ind & Ir—May 5, 1899. No. 27602 A.

Clutch.

A Combined Friction and Positive Clutch. Illustrated description of a clutch in successful use in Germany and England, and recently patented in the United States by Jacob Missong. It possesses new and interesting features. 700 w. Am Mach —May 4, 1899. No. 27471.

Coining.

The Making of Coining Dies. (La Fabrication des Monnaies.) Illustrating and describing the machine used at the Paris Mint for reproducing, on a reduced scale, the designs for dies, for coins, medals, etc. 1200 w. Genie Civil—April 15, 1899. No. 27801 D.

Coke.

Foundry Coke. Walter J. May. Discusses the question of good foundry coke. 1000 w. Prac Engr—May 5, 1899. No. 27631 A.

Cupolas.

Cupola Capacity—Tuyere Area and Arrangement—Blast Pressure—Charging Cupolas—Design for a Cupola. L. C. Jewett. Briefly considers the subjects named. 1300 w. Am Mach—May 4, 1899. No. 27470.

Cylinders.

Making Corliss Cylinders. Joseph Horner. illustrated description of the methods employed in construction. 1400 w. Mech Wld—April 28, 1899. Serial. 1st part. No. 27552 A.

Dies.

Cast Iron Dies. R. I. Clegg. Particulars concerning the use and capacity, the molding and pattern making in getting out the die and tools. Ill. 1300 w. Am Mach —May 11, 1899. No. 27564.

Making a Punch and Die in a High-Pressure Machine Shop. A. H. Cleaves. Illustrated description. 500 w. Am Mach—May 25, 1899. No. 27753.

Etching.

Acid Blast Process for Etching. Louis Edward Levy. Abstract of a paper on a new method of etching. Ill. 2500 w. Jour Fr Inst—May, 1899. No. 27500 D.

Foundry Irons.

Blast Furnace Compared with Cupola Practice. Edgar S. Cook. Read before the Foundrymen's Assn., Philadelphia. Discusses casting machines, fracture, sandy iron, temperature and sulphur, atmospheric moisture, chill, sampling, etc. 6300 w. Ir Age—May 11, 1899. No. 27563.

Foundry Practice.

Foundry Practice at the Close of the 19th Century. (Der Giessereibetrieb am Ende des Neunzehnten Jabrhunderts.) A Ledebur. A general review of the development of foundry practice during the

latter half of the century, with a number of fine views and plans of the foundries of Borsig, at Berlin, and Sulzer Bros. at Winterthur. 12,000 w. 7 plates. Zeitschr d Ver Deutscher Ing—April 22, 1899. No 27816 D.

Handling Materials.

Handling Materials in a Foundry. W. J. Keep. Abstract of a paper presented at the Pittsburg meeting of the Am. Found. Assn. Illustrates and describes the methods in use at the works of the Michigan Stove Co., Detroit Mich. 4000 w. Ir Age—May 25, 1899.. No. 27748.

Machine Design.

Speeds and Feeds of Machine Tools. C. C. Stutz. Suggestions for machine tool designers, with explanation of a simple and quick method for obtaining a geometrical progression of speeds and feeds in machine drives. Ill. 3500 w. Mach. N. Y. —May, 1899. No. 27409.

Machine Tools.

The Productive Capacity of Machine Tools. (La Production des Machines-Outils.) MM. Huillier & Fremont. A valuable paper, giving the results of dynamometric tests upon various tools, showing the power required for the production of a given result. 8000 w. Bull de la Soc. d'Encour—April, 1899. No. 27 809 G.

Paper Mill.

American Wood Cutting and Pulping Mills. (Amerikanische Schneidemühle und Entrindungsanlage.) F. Stallmaier. A description of the arrangement of mills for grinding wood into paper-pulp as practiced in Canada and the United States. 1000 w. Zeitschr d Ver Deutscher Ing—April 22, 1899. No. 27818 D.

Pig Iron.

The Position of Pig Iron. Editorial discussion of the present situation, which threatens a famine of pig-iron supplies. 2500 w. Engr, Lond—April 21, 1899. No. 27425 A.

Precision Machinery.

Professor W. S. Roger's Precision Lathe. An account of the methods used in this machine, which was destroyed by fire, and whose inventor is dead, with editorial on the call for this class of machinery. 2500 w. Am Mach—May 25, 1899. No. 27751.

Printing Presses.

Some Printing Press Movements. Franklin Sweet. Describes the vital movements of a press showing how difficult are some of the problems. Ill. 3800 w. Wis Engr—May, 1899. No. 27662 D.

Projectiles.

Making of Projectiles. J. A. Murphy. Describes the making of shells and gives hints on the construction of patterns, core boxes, flasks, etc. 1200 w. Foundry—May, 1899. No. 27705.

Repair-Ship.

See Marine and Naval Engineering.

Screw-Cutting.

"Catching the Thread" in Screw-Cutting After Running the Carriage Back by Hand. Explains the principles of a device used by the R. K. Le Blond Machine Co., of Cincinnati. Ill. 800 w. Mach. N. Y.—May, 1899. No. 27411.

Shafting.

See Marine and Naval Engineering.

Shafts.

Hollow-Bored Shafts as Made by the Cast Steel Works of Fried. Krupp, Germany. George H. Bryant. Illustrated description of the processes used, a statement of the advantages of hollow shafts, and information concerning material, etc. 3500 w. Wis Engr—May, 1899. No. 27-658 D.

Shops.

The Shops of the Landis Tool Company. Illustrated description. 1400 w. Am Mach—May 25, 1899. Serial. 1st part. No. 27752.

Tools.

Machine Tools. Ewart C. Amos. Abstracted from a paper read before the Soc. of Engs. Considers the distinctive features of modern tools and compares British and American tools. 3300 w. Mech Wld —April 21, 1899. No. 27414 A.

Wages.

Methods of Remunerating Labor. P. J. Darlington. A critical comparison of the piece-work, piece-rate, and premium systems of remunerating labor, setting forth the advantages of the piece-rate system. 4000 w. Engineering Magazine—June, 1899. No. 27896 B.

Works Management.

Machine Shop Management in Europe and America. H. F. L. Orcutt. Mr. Orcutt's sixth paper compares the various systems used in Europe and America with respect to the important questions of output, price and quality. 4000 w. Engineering Magazine—June, 1899. No. 27-892 B.

Wrenches.

Proportions for Wrenches. Information upon the subject of open-end wrenches. Ill. 900 w. Mach, N. Y.—May, 1899. No. 27 410.

MATERIALS OF CONSTRUCTION.

Hardening.

The Stresses in Large Sections of Hardened Steel. (Ueber Spannungen im Gehärteten Stahle Grosseren Querschnitts.) Otto Thallner. A discussion

of the internal stresses produced by the molecular changes consequent upon hardening, with illustrations and data from many experiments. 3500 w. Stahl und Eisen—April 1, 1899. No. 27851 D.

Overstrain.

On the Recovery of Iron from Overstrain. James Muir. Such recovery is known to be affected by time; and a summary of experiments is given showing the effect of moderate temperature, mechanical vibration, and magnetic agitation, giving compression tests illustrating the recovery. 1300 w. Engr, Lond—April 28, 1899. No. 27539 A.

Samples.

The Utility of Chemically Standardized Iron Samples. Albert W. Smith. Read before the Am. Found. Assn. Discusses the circumstances that influence the manner of combination of the elements in chemical composition. 1500 w. Ir Age—May 25, 1899. No. 27749.

Specification.

Notes on Specifications for Cast Iron Water and Gas Pipes. C. A. Meissner. Read before the Min. Soc. of Nova Scotia. Calls attention to points in the average specification that seem very unnecessary, and submits a concise specification covering all points. 2200 w. Can Min Rev—April 29, 1899. No. 27408 B.

Strains.

Instruments for Measuring Small Torsional Strains. E. G. Coker. Read before the British Assn. for the Adv. of Science. Illustrates and describes two arrangements of apparatus intended for use in engineering laboratories and testing houses for measuring such strains, and for the determination of the modulus of rigidity. 1700 w. Can Engr—May, 1899. No. 27557.

Testing.

Standards for Testing Cast Iron. A report by the committee of the A. F. A., on the progress of cast iron. 3300 w. Ir Trd Rev—May 18, 1899. No. 27667.

POWER AND TRANSMISSION.

Belt Dressing.

A New Belt Dressing. Extracts from a report of R. C. Carpenter in regard to tests recently made of a new dressing made by the Cling-Surface Manufacturing Co., of Buffalo, to determine the effect of running with and without the preparation under various conditions of loading. 900 w. R R Gaz—May 5, 1899. No. 27496.

Coal Handling.

Notes on Coal Handling Machinery. Discusses correct designs in bearings, tension, the belt, power of the engine, fixing pipes to storage tanks, etc. Ill. 2000 w. Am Mfr & Ir Wld—April 28, 1899. No. 27386.

Compressed Air.

Economy of Compressed Air Power Transmission. William O. Webber. On the possibilities of this method of storing and converting energy, and the cost of development. 1100 w. Compressed Air—May, 1899. No. 27551.

Windmills and Compressed Air. Frank Richards. Considers a proposition to pump air and store it for power, showing that the scheme is not practical. 1200 w. Am Mach—May 18, 1899. No. 27641.

Lifting Machinery.

Some Recent Improvements in Cranes and Lifting Machinery. Edward C. R. Marks. Part first deals with rope and chain pulley blocks, giving illustrations. 1200 w. Prac Engr—April 21, 1899. Serial. 1st part. No. 27416 A.

Power Calculations.

The Calculation of Power. W. H. Wakeman. Points out errors in rules used and explains why they are errors. 2200 w. Mod Mach—May, 1899. No. 27477.

Power Gas.

The Application of Blast Furnace Gases for Operating Gas Engines. (Die Verwendung der Hochofengichtgase zum Betriebe von Gasmotoren.) E. Meyer. A general examination of the applicability of furnace gases for motive power, and details of trials made with blast furnace gas upon a 60 h.p. motor at the Differdingen furnaces in Luxemburg. Two articles, 10,000 w. Zeitschr d Ver Deutscher Ing—April 22 and 29, 1899. No. 27817 each D.

Power Plant.

The James River, Va., Water-Power Development. William Todd. Illustrates and describes the plans of a work now in progress. 1800 w. Elec Wld & Elec Eng—May 6, 1899. No. 27491.

The Proposed Power Plants in the Wäggithal and on the Etzel. (Die Projektierten Kraftanlagen in Wäggithal und am Etzel.) With a map and description of these proposed plants near Zurich, by which more than 80,000 h.p. will be secured. Schweizerische Bauzeitung—April 22, 1899. No. 27834 B.

Shafting.

See Marine and Naval Engineering.

Shafts.

See Machine Works and Foundries.

SPECIAL MOTORS.

Diesel Motor.

The Diesel Motor. Rudolph Diesel. Translation of a report in the *Zeitschrift des Vereines Deutscher Ingenieur*. Gives illustrations of recent motors and an account of experiments with various fuels.

1800 w. Pro Age—May 1, 1899. Serial. 1st part. No. 27384.

Gas Engines.

A Simple Gas Engine. Illustrates and describes an arrangement designed by Harry J. Perkins. 600 w. Am Mach—May 4, 1899. No. 27472.

A 650-H.P. Gas Engine Direct Connected to a 520 K.W. Electric Generator. Brief illustrated description of this Westinghouse engine. 700 w. Engs News—May 4, 1899. No. 27465.

Some Suggestions as to the Care and Management of Gas Engines. E. C. Hathaway. General suggestions for their operation and care. 1600 w. Am Gas Lgt Jour—May 8, 1899. No. 27514.

The New Era Gas Engine. B. A. Illustrates and describes this engine. 800 w. Am Mach—May 18, 1899. No. 27642.

Windmills.

Electric Power from Windmills. C. L. Crandall. The substance of this paper was presented at the Boston meeting of the Am. Assn., for the Adv. of Science. Requests for more information led to the preparation of this paper, which gives the lamp hours a day available for electric lighting from a storage battery plant driven by a 12-foot aermotor. 1200 w. R R Gaz—May 5, 1899. No. 27498.

STEAM ENGINEERING.

Balancing.

A Curious Problem in Balancing. Charles P. Paulding. Explains the problem and the graphical construction showing how satisfactory is this method of computation. 1300 w. Am Mach—May 4, 1899. No. 27469.

The Balancing of Engines, with Special Reference to Marine Work. W. E. Dalby. Read before the British Inst. of Naval Archts. Explains and illustrates a semi-graphical method of treating balancing problems in a direct and simple manner. Also discusses the proper treatment of the connecting rod. Ill. 5000 w. Engng—April 21, 1899. Serial. 1st part. No. 27434 A.

Blowing Engine.

Blowing Engine at the Krompach Works. Illustrates and describes engines built for blast-furnace use, giving the leading dimensions. 500 w. Engr, Lond—April 21, 1899. No. 27426 A.

Blowing Engines for Blast Furnaces. (Hochofen-Gebläsemaschine.) Fritz Lamey. An illustrated description of the powerful compound blowing engines built by the Elsass Machine Works at Mülhausen for the Krupp Works at Rheinhausen; with details, and sectional elevation. 2000 w. 1 plate. Zeitschr d Ver Deutscher Ing—April 15, 1899. No. 27814 D.

Boiler Explosions.

The Explosions of the Boilers of H. M. S. "Terrible." Editorial on the explosions of this vessel's boilers, suggesting that the ship be reboilered with some other type of water tube than the Belleville. 1400 w. Engr Gaz—May, 1899. No. 27534 A.

Chimney.

The Great Chimney of the La Bourdonnais Power House on the Champ-de-Mars. (La Cheminée Monumentale de l' Usine La Bourdonnais au Champ-de Mars.) Ch. Dantin. An account of the design and construction of the great chimney for the power-house of the Exposition of 1900, with elevation and section, and photographs of the excavations for the foundation. 2500 w. Génie Civil—May 6, 1899. No. 27804 D.

Combustion.

Gas Analysis and Furnace Economy. A. Bement. Showing the value of an accurate knowledge of the state of combustion. 2000 w. Mod Mach—May, 1899. No. 27475.

Condenser.

Condensation in Steam Engines. From *La Nature*. An improved form of ejector condenser adapted to use the same condensing water repeatedly. 1000 w. Sci Am Sup—May 20, 1899. No. 27644.

Evaporative Condensers. Harry G. V. Oldham. From a paper read before the Inst. of Mech. Engs., England. Illustrates and describes the methods of Theisen, Wright, Fraser and Ledward. 5500 w. Col Guard—April 28, 1899. No. 27547 A.

Cornish Engine.

Cornish Engine, Basset Minis. Illustrates and describes a compound, high-pressure Cornish engine, which has been recently erected at Cornwall, with an account of the trial. 1000 w. Engr, Lond—May 12, 1899. No. 27725 A.

Economy.

Steam Boiler Economy. William Kent. Considers especially the heating value of different coals, with three points bearing on economy. 5400 w. Sib Jour of Engng—May, 1899. No. 27761 C.

Engines.

Compound and Condensing Engines. Alfred Siebert. Discusses when it is advisable to condense and when to compound, and other related subjects. 2800 w. Ice & Refrig—May, 1899. No. 27456 C.

Economy of Multiple Expansion Engines. William S. Aldrich. Considers the effects of changes of load, systems of installations, speed regulations, etc., in relation to the economical working. 2700 w. Am Elect'n—May, 1899. Serial. 1st part. No. 27482.

The New 2000-Horse-Power Engines and Alternator at Deptford. Illustrated detailed description. 1700 w. Engr, Lond—April 21, 1899. No. 27424 A.

Vertical Steam Engines. (Stehende Dampfmaschinen.) G. Marx. A very full review of the more recent designs of the leading German builders, with numerous illustrations. 6000 w. Zeitschr d Ver Deutscher Ing—May 13, 1899. No. 27823 D.

Engine Design.

The Application of Combined Diagrams in the Design of Compound Engines. (Die Mittel zur Erzilung des Gewünschten Diagramm-verlaufes bei der Konstruktion des Diagramms einer Verbunddampfmaschine.) H. Lynen. Showing the method of applying the combination of ideal indicator diagrams to the proportioning of compound engines. 4500 w. Zeitschr d Ver Deutscher Ing—April 29, 1899. No. 27819 D.

Engine Test.

Test of a Nordberg Pumping Engine in the Pumping Station of the Pennsylvania Water Company, at Wildwood Station, Pittsburg, Pa. R. C. Carpenter. Describes the engine and tests, giving the general results. 4200 w. Sib Jour of Engng—April, 1899. No. 27352 C.

Expansion.

Economy as Effected by Expansion. C. H. Brustlein. Showing the effect of the variation of the ratio of expansion, upon the ideal engine, and the modifications introduced by the imperfections of the real engine. 2000 w. Sib Jour of Engng—April, 1899. No. 27354 C.

Flow.

The Flow of Steam in Locomotive Cylinders. (Die Dampfeinströmung in die Cylinder der Lokomotiven.) A mathematical discussion by Inspector Leitzmann, with curves constructed for various pressures and port openings. 3000 w. Glasers Annalen—April 15, 1899. No. 27848 D.

Fuel.

Adapting the Coal to the Grates, Draught, etc., and Vice Versa. H. H. Kelley. Considers the economy and advantage of selecting coal suited to the type of boiler, draught, and grate-bars used. 2700 w. Engr, U. S. A—May 15, 1899. No. 27628.

Furnace.

A Test of the Murphy Automatic Furnace. A. W. Richter. A brief illustrated description of the furnace and test made, giving data and results. 1700 w. Sib Jour of Engng—April, 1899. No. 27353 C.

Generators.

Improvements in Steam Generators. (Dispositif Applicable aux Générateurs de Vapeur.) An illustrated description of a steam generating system in which the water is supplied to the boiler in direct proportion to the consumption of steam. 2000 w. Revue Technique—April 25, 1899. No. 27808 D.

Governing.

An Electric Governor. (Régulateur Electrique.) Ch. Gruet. An illustrated description of a system by which the speed of the steam engine is governed directly from the dynamo instead of using centrifugal force. 1500 w. Revue Technique—May 10, 1899. No. 27813 D.

The Controlling Power of Governors. Translated from *Zeitschrift des Vereines Deutscher Ingenieure.* Remarks explanatory of the forces in the governor, and their action. Mathematical determination of the power available. 3500 w. Mech Wld—May 12, 1899. No. 27708 A.

The Siemens' Regulating Principle and the American Inertia Governors. (Das Siemenssche Regulirprinzip und die Amerikanischen "Inertie-Regulatoren.") A. Stodola. An exhaustive examination of the inertia principle as applied to steam engine governors, showing the anticipation of the modern governors by the Siemens' governor of 1845. Serial. Part 1. 8000 w. Zeitschr d Ver Deutscher Ing—May 6, 1899. No. 27820 D.

Heat-Absorption.

Experiments on the Heat Absorption of Water. An account of experiments carried out by Mr. G. Halliday in the Inst. of Marine Engs. (England), to ascertain the heat absorptive power of water at different temperatures and different ratio of velocity across the surfaces. 1500 w. Engr, Lond—May 12, 1899. No. 27726 A.

Indicator.

Some Uses of the Steam Engine Indicator. Edward F. Miller. Read before the New England Ry. Club. Discusses the use in setting valves and in determining some defects. Ill. 2500 w. R R Gaz—May 26, 1899. No. 27770.

Marine Engines.

See Marine and Naval Engineering.

Meter.

Apparatus for Measuring Steam. (Dampfmess-Apparate.) An illustrated description of the Lindenheim steam meter, in which the induced flow of steam in a nozzle is used to measure the volume passing. 2000 w. Gesundheits-Ingenieur—April 15, 1899. No. 27855 B.

Mill Engines.

Rolling-Mill Engines. (Motoren zum Antrieb der Walzenstrassen.) C. Kieselbach. A discussion of the difficult conditions of operation in rolling-mill practice, together with plan and elevation of tan-

dem compound engines designed for such service. Serial. Part 1. 4000 w. Zeitschr d Ver Deutscher Ing—May 13, 1899. No. 27826 D.

Smoke.

Smoke Consumption and Economy of Fuel. Describes the process of Paul Cornelius for the consumption of low-grade fuels, as exhibited in an installation in Berlin, and at Guben, reporting results and tests. 1500 w. U. S. Cons Repts, No. 431.—May 20, 1899. No. 27686 D.

Steam Consumption.

Steam Consumption of Auxiliary Engines in Warships. Editorial noting some of the machinery difficulties in connection with higher pressures and the efforts being made to overcome them. 3000 w. Engng—April 21, 1899. No. 27433 A.

Steam Turbine.

The Theory of the Steam Turbine. (Theorie der Dampf-Turbinen.) A. Fliegner. A thorough mathematical discussion of the subject, showing the difference between pressure and reaction turbines, and the conditions which conduce to the highest efficiency. Five articles. 7500 w. Schweizerische Bauzeitung—March 25, 31, April 15, 29, May 6, 1899. No. 27831 each B.

Stoker.

Smokeless Firing with Inclined Grate. (Rauchfreie Verstellebarre Schrägfeuerung.) H. Karft. An illustrated description of an improved stoker by use of which smokeless combustion may be attained. 2000 w. Zeitschr d Ver Deutscher Ing—May 6, 1899. No. 27822 D.

Superheating.

The Production and Application of Super-heated Steam. (Der Ueberhitzte Wasserdampf seine Erzeugung und Verwendung.) H. Hoff. With many illustrations of the latest designs of successful superheaters and engines for use with superheated steam. 4000 w. Stahl und Eisen—April 15, 1899. No. 27854 D.

Triple-Expansion.

Wigzell's Triple-Expansion Engine. Illustrated description. 800 w. Engng—May 5, 1899. No. 27614 A.

Water Tube.

See Marine and Naval Engineering.

Yarrow Boiler.

See Marine and Naval Engineering.

MISCELLANY.

Address.

The Development in Technical Industry During the Past Fifty Years. (Zur Entwicklung der Technischen Wissenschaften und Künste in den Letzten Fünfzig Jahren.) Anton Rücker. The memorial address delivered at the fiftieth anniversary of the Austrian Society of Engineers and Architects reviewing the progress of the half-century. 10,000 w. Zeitschr d Oesterr Ing w Arch Ver—May 12, 1899. No. 27830 B.

Bicycles.

The Efficiency of the Bicycle. Robert H. Fernald. A study of the bicycle as a machine, calling attention to interesting points in connection with its efficiency. Ill. 2500 w. Jour Assn of Engng Socs—March, 1899. No. 27381 C.

The Folding Military Bicycle. From *La Nature*. Particulars and illustrations of recent improvements in this machine. 900 w. Sci Am Sup—May 20, 1899. No. 27646.

Gun Explosion.

High Explosives and Big Guns. Editorial on the explosion at the Sandy Hook testing grounds and the behavior of smokeless powder. 1900 w. Ind & Ir—April 28, 1899. No. 27535 A.

Hose.

The Evolution of Fire Hose and Circular Hose Weaving. Gives the historical account of the hose manufacture in the United States. 1500 w. Ind Rub Wld—May 1, 1899. Serial. 1st part. No. 27499 D.

Japan.

The Industrial Situation in Japan. Lamar Lyndon. Devoted especially to Japan as a machinery market and discussing the national characteristics of the people considered as machinery buyers and makers. 3000 w. Engineering Magazine—June, 1899. No. 27898 B.

Liquid Air.

Liquid Air and the Power Required to Produce It. A. H. Neureuther. Describes the usual methods employed to produce liquid air, and gives a statement relating to the power required, with discussion of the amount of work theoretically possible to get from liquid air. Ill. 2700 w. St Ry Rev—May 15, 1899. No. 27733 C.

Liquid Air. Ira Remsen. Explains the method employed in its production, gives an account of some of its properties, and indicates some of the uses to which it may be applied. 5300 w. Ap Pop Sci M—May, 1899. No. 27350 D.

Mr. Tripler and Liquid Air. Madison Cooper. An examination of the claims made for the Tripler process, and a discussion of the probable limitations in the application of liquid air to engineering purposes. 2300 w. Mod Mach—May, 1899. No. 27476.

Power from Liquid Air. A criticism of statements credited to Mr. Tripler, and reported in *McClure's Magazine*. Also remarks on views of W. C. Peckham. Ill. 3600 w. Power—May, 1899. No. 27369.

MINING AND METALLURGY

COAL AND COKE.

Belgium.

Special Features at the Aiseau-Presles Colliery, Belgium. M. J. Collin. Particulars from the paper presented to the Assn. des Ingenieurs de Liege. Describes the breakage, overhead haulage by wire tramway, the adoption of sheer legs for the principal winding shaft, and the emergency hauling engine. 1800 w. Col Guard—May 5, 1899. No. 27609 A.

British Coal.

Our Coal Supplies. T. Forster Brown. A discussion of the problems that must be solved by Great Britain in the near future, especially as regards increase of cost. Discussion. 9800 w. Jour Soc of Arts—April 28, 1899. No. 27520 A.

Burning Mines.

The Burning Mines of Summit Hill. W. C. Morganroth. The origin of the fire and the conditions which have rendered efforts to extinguish it ineffectual. 3500 w. Mines & Min—May, 1899. No. 27437 C.

Carboniferous Beds.

The Correlation of the British and European Carboniferous Beds. Dr. Wheelton Hind. Address delivered before the Manchester Geological Soc. Discusses the question of the correlation of the beds below the millstone grit. 3500 w. Col Guard—April 21, 1899. Serial. 1st part. No. 27428 A.

Coke.

See Mechanical Engineering, Machine Works and Foundries.

Coking.

The Manufacturing of Short Coke. States some of its advantages and the principles on which its formation depends. 1300 w. Mines & Min—May, 1899. No. 27446 C.

The Von Bauer Coking Plant. Julius Elsner in *Stahl und Eisen.* Illustrates and describes the system and method of working, giving a comparison of results. 1600 w. Col Guard—April 28, 1899. No. 27546 A.

Colonial Mines.

Coal Mining in the Colonies. Harrison F. Bulman. A summary of the present condition and extent of coal mining in Canada, Australia and New Zealand. 3000 w. Col Guard—April 28, 1899. No. 27542 A.

Counterpoise.

Winding Rope Counterpoise at a Prussian Colliery. Oberbergrath Leybold, in *Zeitschrift für Berg- Hulten- und Salinenwesen.* Illustrates and describes an appliance which has been in use for some years and is considered satisfactory. 1800 w. Col Guard—April 28, 1899. No. 27543 A.

Head Gears.

Colliery Head Gears—Past and Present. Illustrates and describes the radical changes in this feature of colliery equipment, beginning with the simple device used in early days of coal mining. 900 w. Ir & Coal Trds Rev—April 21, 1899. Serial. 1st part. No. 27421 A.

Labor Saving.

Labor-Saving Devices in Use at a Pennsylvania Anthracite Mine. L. C. Morgenroth. Calls attention to the importance of the details in mining, giving examples of ingenious devices used in a mine recently visited. Ill. 2000 w. Eng & Min Jour—May 13, 1899. Serial. 1st part. No. 27629.

Long Haulage.

The Longest Mine-Haulage. F. Z. Schallenberg. An account of a visit to the Keeling coal mine, near Pittsburg. 1100 w. Trans Am Inst of Min Engs—Feb., 1899. No. 27346 D.

Micro-Organisms.

Micro-Organisms of Coal. B. Renault, in *Naturwissen Schaliche Rundschau.* A brief account of investigations. 1200 w. Col Guard—May 5, 1899. No. 27607 A.

Mine Flooding.

New Method of Mine Flooding. Illustrated description of the method adopted by the Pennsylvania Coal Company for subduing a fire in their No. 6 shaft. 900 w. Mines & Min—May, 1899. No. 27441 C.

Oven.

The Von Bauer Coke Oven. (Koksöfen von Dr. von Bauer.) Julius Elsner. A fully illustrated description of the von Bauer ovens as installed in the Krupp works at Hannover. 2500 w. Stahl und Eisen—April 15, 1899. No. 27853 D.

Production.

Coal Production of the Principal Countries of the World. Statistics from the annual statement of the British Board of Trade. 2200 w. Col Guard—May 12, 1899. No. 27720 A.

Scotch Coals.

Chemical Notes on Scotch Coals. W. C. Anderson. Abstracted by the *Journal of the Soc. of Chem. Ind.* from the Proceedings of the Glasgow Philosophical Soc. Considers the varieties, the cak-

ing power, oxidation, etc. 2000 w. Prac-Engr—April 28, 1899. No. 27532 A.

Shaft Sinking.

Sinking Shafts Through Quicksand at Bascoup Colliery, Belgium. Edward Briart. From a communication to the Société des Ingenieurs des Mines du Hainaut. Describes and illustrates the methods adopted. Notwithstanding serious difficulties, the work was satisfactorily carried out. 3000 w. Col Guard—April 21, 1899. No. 27429 A.

Sinking the Hugo Shaft Near Holten. Oeberbergrath Selbach, in *Zeitschrift für Berg-Hutten- und Salineenwesen*. An account of a difficult piece of work followed by disaster which ruined the labor of three years and incurred a loss of some £37,000. Ill. 1400 w. Col Guard—May 5, 1899. No. 27608 A.

Sizing.

The Effect of Sizing on the Removal of Sulphur from Coal by Washing. Charles C. Upham. On the importance of the finer crushing of coal before washing, with suggestions, observations and experiments. 1400 w. Am. Gas Lgt Jour—May 8, 1899. No. 27515.

Utah.

Coal Mines of Utah and Coal Mining in Utah Fields. Don Maguire. Information in regard to the deposits and their quality, with a history of the early use of coal in the State, and a description of the present development of the industry at the mines of Scofield, Castle Gate, etc. Ill. 2700 w. Mines & Min—May, 1899. No. 27435 C.

West Virginia.

The Thacker Coal Field of West Virginia. Andrew Roy. A description of the formations and the extent and manner of their development. 1200 w. Mines & Min—May, 1899. No. 27445 C.

COPPER.

America.

American Copper-Mining. Editorial on the various sources of the American supply, and some comment on the copper combine. 2500 w. Engng—May 5, 1899. No. 27615 A.

Arizona.

The Copper Mines and Districts of Arizona. G. Frank Judson. Describes the geological formation of the country and the deposits, and mines in operation. 3300 w. Min Rept—May 8, 1899. No. 27763.

Vermont.

Copper Mines in Vermont. Brief account of the mines, ores, etc. 1100 w. Eng & Min Jour—May 20, 1899. No. 27675.

GOLD AND SILVER.

Brazil.

Diamond and Gold Mining in Minas Geraes. Extracts from a report of this region by Mr. Dawson, who has recently visited the country. 8500 w. U. S. Cons-Repts. No. 424—May 12, 1899. No. 27583 D.

British Columbia.

Mining on Vancouver and Texada Islands. W. M. Brewer. A report of these districts, which have been recently visited by the writer. 1700 w. Eng & Min Jour—May 6, 1899. No. 27518.

Texada Island. Alfred Raper. A description of the deposits and development of a young and promising British Columbia mining field. 2000 w. Mines & Min—May, 1899. No. 27439 C.

California.

California Gold Mines. Arthur Lakes. Illustrates and describes some typical mines situated in Grass Valley, Nevada Co., California, and their high-pressure water-power plants used for the production of compressed air. 3000 w. Mines Min—May, 1899. No. 27438 C.

Some Characteristic Mines of the California Gold Belt. W. H. S. Describes some of the characteristics peculiar to each type of vein. 1800 w. Min & Sci Pr—May 20, 1899. No. 27777.

Colorado.

The Liberty Bell Gold Mine, Telluride, Colorado. Arthur Winslow. Treats of the location, history, geology, ore composition and values, ore treatment, milling and mining methods. Ill. 4800 w. Trans Am Inst of Min Engs—Feb., 1899. No. 27344 D.

Cyanide.

A Zinc Process for precipitating Gold from Weak Solutions. T. L. Carter. A reply to the discussion of the writer's paper, with a continuation and close of the discussion. 8800 w. Jour of Chem & Met Soc of S Africa—March, 1899. No. 27664 E.

Darien, S. A.

Modern Gold Mining in the Darien. Notes on the Re-opening of the Espiritu Santo Mine at Cana. Ernest R. Woakes. An interesting account of the writer's experience at this mine. Ill. 11700 w. Trans Am Inst of Min Engs—Feb., 1899. No. 27348 D.

Dredging.

Dredging for Gold. C. C. Longridge. Gives a review of the history of gold dredging, the various dredges used, etc., in part first. 3500 w. Engng—April 21, 1899. Serial. 1st part. No. 27431 A.

Gold Veins.

The occurrence of Free Milling Gold

Veins in British Columbia. Wm. Hamilton Merritt. Read before the Canadian Min. Inst. Describes veins of high-grade ore, the granite and schitose quartzite. 1700 w. Can Min Rev—April 29, 1899. No. 27405 B.

Klondike.

Alaska and the Klondike. Angelo Heilprin. Part first describes the writer's journey to this region, in by the White Pass and out by the Chilkoot. Ill. 3800 w. Ap Pop Sci M—May, 1899. Serial. 1st part. No. 27349 D.

Laboratory Tests.

Notes on the Results of Some Laboratory Concentrating Tests of the Ores of Faribault Brook, C. B. F. H. Mason. Read before the Min. Soc. of Nova Scotia. Describes experiments. 1400 w. Can Min Rev—April 29, 1899. No. 27403 B.

Leadville, Col.

Some Notes on the Geology of Leadville, Colorado. Describes the sedimentary deposits in their order, ore deposits, etc. 2300 w. Min & Sci Pr—May 20, 1899. No. 27779.

Mining.

The Minting of Gold and Silver. J. Foster Symes. Brief description of the operations. 2300 w. Yale Sci M—May, 1899. No. 27617 C.

New Zealand.

Great Barrier Island. Albion S. Howe. Describes the locality, the workings and ores. 1500 w. N Z Mines Rec—March 16, 1899. No. 27709 B.

Nova Scotia.

Gold Mining in Nova Scotia from 1860 to 1899. Dr. A. R. C. Selwyn. Showing that mining enterprise has been neglected, and discussing the reasons. 1700 w. Can Min Rev—April 29, 1899. No. 27407 B.

Ontario.

The Gold Bearing Veins of Bag Bay, Near Lake of the Woods. Peter Mackellar. Describes the peculiar features, the smallness of the quartz-fisssures as compared with the size of the ore-bearing lodes, and the operations of the Tycoon, Toronto and Western, and Mikado Co.'s. 4000 w. Trans Am Inst of Min Engs—Feb., 1899. No. 27345 D.

Placer Mines.

Forest Hill Placer Mines. Arthur Lakes. How the ancient river beds of Placer County, California, now in the mountain tops, are worked. 1500 w. Mines & Min—May, 1899. No. 27447 C.

Placer Mining and the Future Possibilities of this Branch of the Mining Industry. John W. Gray. A discussion of the outlook in California, especially, for this system of mining. 2000 w. Min & Sci Pr—May 6, 1899. No. 27574.

Prospecting.

An Incident in Systematic Prospecting Connected with the Discovery of the "Rose" Lead, Montague, N. S. George W. Stuart. Read before the Min. Soc. of Nova Scotia. Showing that a knowledge of glacial geology is a great help in prospecting, if not a necessity. 900 w. Can Min Rev—April 29, 1899. No. 27402 B.

La Sal Mountains. Arthur Lakes. A description of the region about La Sal mountains, including Paradox Valley, which has lately been attracting attention, and of which there is little definite information. Ill. 2500 w. Mines & Min—May, 1899. No. 27443 C.

Observations on Some Prospects and Mines Around Breckenridge, South Park, Colorado. Arthur Lakes. Notes taken in a trip made to examine a gold placer property. Ill. 1600 w. Mines & Min—May, 1899. No. 27436 C.

The Diamond Drill in Prospecting. Some points on the manner of using. 1200 w. Min & Sci Pr—May 13, 1899. No. 27666.

Stamp Mills.

The Adjustments and Control of the Stamp Mill. Courtenay De Kalb. Read before the Can. Min. Inst. The importance of determining the design of mill required, of guarding the details of practice, and adapting the treatment to the ore. 4500 w. Can Min Rev—April 29, 1899. No. 27406 B.

Western Australia.

The Kalgoorlie District in Western Australia. Facts concerning the output and treatment of the ores. 900 w. Eng & Min Jour—May 27, 1899. No. 27775.

Yukon.

Preliminary Notes on the Surface Geology of the Yukon Territory. Otto Nordenskjold. Report of observations made on a journey between the Alaska coast and Dawson City. 3500 w. Am Geol—May, 1899. No. 27549 D.

IRON AND STEEL.

American Conditions.

The American Iron and Steel Industries. A Comparison. Walter Dixon. Read before the West of Scotland Iron & Steel Inst. Impressions of an Englishman on visiting American works. Considers the management, labor, resources, and part played by electricity, with conclusions. 4000 w. Col Guard—April 21, 1899. No. 27430 A.

Analysis.

Pig Iron Analysis. Edmund E. Johnston. A comparative statement of results obtained by different chemists from the same piece of pig iron. 3000 w. Ir Age—May 18, 1899. No. 27653.

Blast-Furnace Gas.

The Use of Blast-Furnace and Coke-Oven Gases. Enrique Disdier. Read before the British Iron and Steel Inst. Considers the disadvantages of these gases as compared with others, and discusses methods of installing coke ovens adjacent to blast-furnaces, and the advantages that accrue. 3500 w. Ind & Ir—May 12, 1899. No. 27718 A.

Blast Furnaces.

The Manufacture of Steel Direct from the Ore in the Blast Furnace. Dimitris Tschernoff. Read before the British Iron and Steel Inst. Illustrates and describes a construction of blast-furnace by which this may be attained. 700 w. Col Guard—May 12, 1899. No. 27722 A.

Blowing Engines.

See Mechanical Engineering, Steam Engineering.

Cast Iron.

See Mechanical Engineering, Machine Works and Foundries.

Diffusion.

The Diffusion of Elements in Iron. John Oliver Arnold and Andrew M'William. Abstract of a paper read at meeting of the British Ir. and Steel Inst. Illustrates and describes the experimental methods adopted, giving the results of analysis, details of experiments, etc. 3000 w. Ir & Coal Trd Rev—May 5, 1899. No. 27606 A.

Gellivare Mines.

The Gellivare Iron Ore Mines. H. Bauerman. Describes the location, deposits, working, shipping, etc. 2700 w. Col Guard—May 5, 1899. No. 27611 A.

Hot Blast.

The Use of Hot Blast in the Bessemer Process. J. Wilborgh. Read before the Ir and Steel Inst. On the advantags of the use of the hot blast for the basic Bessemer process and for small converters. 2000 w. Col Guard—May 5, 1899. No. 27610 A.

Lorraine.

The Iron Ore Deposits of German Lorraine. (Die Minetteablagerung Deutsch-Lotringens.) W. Albrecht. With geological map and sections of the workings. Two articles, two plates. 7500 w. Stahl und Eisen—April 1, 15, 1899. No. 27850, each D.

Open-Hearth.

On Tilting Open-Hearth Furnaces. Archibald P. Head. Illustrated description of the furnace of this type used for the past ten years in the United States, and its advantages. 2700 w. Ir & Coal Trds Rev—May 5, 1899. No. 27603 A.

Ore Concentration.

The Groendal-Dellwick Process for the Concentration of Iron Ore. Dr. Leo, in *Stahl und Eisen*. An account of the vorable results with a large deposit of lean magnetite in Finland, by the use of this process. 1600 w. Am Mfr & Ir Wld—April 28, 189. No. 27385.

Ore Kiln.

Improvement in the Davis-Colby Ore Kiln. Charles J. Christian. Gives the experience of the writer with the kilns as originally constructed and also as modified according to plans shown. 1200 w. Am Mfr & Ir Wld—May 5, 1899. No. 27517.

Pig Iron.

See Mechanical Engineering, Machine Works and Foundries.

Production.

Our Iron and Steel Production in 1898. Information from the statistical report of the Am Iron and Steel Assn,, compiled by James M. Swank. 1500 w. Ir Age—May 25, 1899. No. 27750.

Progress.

Progress in the Iron and Steel Industries. W. Roberts-Austen. Abstract of a presidential address to the Iron and Steel Inst. A consideration of British efforts in connection with these industries. 7000 w. Nature—May 11, 1899. No. 27687 A.

Steel Furnaces.

Mechanical Charging of Steel Furnaces. Henry Tomkins. Abstract of paper and discussion presented at meeting of the Cleveland Inst. of Engs., at Middlesbrough, Eng. Describes a machine invented by the writer, which has given satisfaction during a twelve-month's trial. 3500 w. Col Guard—April 28, 1899. No. 27544 A.

Steel Ingots.

A Method of Casting Steel Ingots. Illustrates and describes a method devised by J. K. Griffith, of casting compound ingots, composed of layers of steel of different composition, to overcome the difficulties from segregation and piping, and to insure homogeneous metal. 1200 w. Ir Trd Rev—May 4, 1899. No. 27478.

Sweden.

The Iron Industry of Sweden. David A. Louis. A very fully illustrated account of the plant and practice of the Swedish mines and iron and steel industry. 4500 w. Engineering Magazine—June, 1899. No. 27895 B.

MINING.

Cave-In.

Cave-In of the Bon Air Shaft at Leadville, Colorado. An account of how it happened and how the men were rescued after fourteen days imprisonment. 1800

w. Mines & Min—May, 1899. No. 27446 C.

Costs.

A Decade of Progress in Reducing Costs. Charles Kirchhoff. Presidential address at the New York meeting. Presents data indicating to what extent improvements in practice and equipment have affected the cost sheet. 3800 w. Trans Am Inst of Min Engs—Feb., 1899. No. 27347 D.

Electricity.

Electricity in Mining Engineering; Its Uses, Advantages and Defects. Philip Evans. Read before the British Soc. of Min. Students. Considers electricity as applied to lighting, signaling, pumping, haulage, blasting, drilling, coal cutting, and winding. 2000 w. Ir and Coal Trds Rev—May 5, 1899. No. 27604 A.

Explosives.

Experiments Connected With the Detonation of Favier Grisounites. A report of numerous experiments made under various conditions. 2500 w. Col Guard—April 28, 1899. No. 27545 A.

The Use of Blasting Explosives. A. H. Stokes. Considers the principle of the Woolwich test, the application of the explosives in coal mines order, and related matter. 4500 w. Col Guard—May 12, 1899. No. 27721 A.

Gases.

On a Hypothesis to Explain the Partial Non-explosive Combination of Explosive Gases and Gaseous Mixtures. W. G. Mixer. Reviews investigations made, and states the writer's views, based on a study of the phenomena of explosives. 2800 w. Am Jour of Sci—May, 1899. No. 27380 C.

Mexico.

Mexican Methods of Mine Management and Operation. George F. Binckley. Describes the system of working and the business management. 420 w. Min & Sci Pr—April 29, 1899. No. 27457.

Mining in Sinaloa, Mexico. John W. Gray. Some notes on the mines of the state and the extent of their development. 2000 w. Mines & Min—May, 1899. No. 27444 C.

Mine Plant.

See Electrical Engineering, Power Applications.

Mining Law.

Mines Under Rivers, the Foreshore, and Streams and Locks. Essential points and facts of decisions pronounced by the high courts of England on this subject. 2500 w. Col Guard—April 21, 1899. No. 27427 A.

Mining Laws of British Columbia. Copy of a placer mining act passed Jan. 18, 1899. 3600 w. U. S. Cons Repts, No. 413—April 29, 1889. No. 27351 D.

The Colorado Mining Law. A copy of the code of regulations provided for mines in operation, which is a part of a new law which goes into effect July 9. 1800 w. Eng & Min Jour—May 27, 1899. No. 27774.

Panel System.

The Advantages of the Panel System. Gives points in regard to ventilation and states the circumstances under which this system is preferable to others. 1200 w. Mines & Min—May, 1899. No. 27442 C.

Water Hoist.

The Tomson Water Hoist. (Das Tomsonsche Wasserziehverfahren.) A description of the method of removing the water from the shaft of the Minister Achenbach mine during the deepening operation. The water was raised in tanks by the mine hoist. 1000 w. 1 plate. Glückauf—May 6, 1899. No. 27861 B.

MISCELLANY.

Alloys.

Quick Testing of Lead-Tin and Lead-Antimony Alloys. Joseph Richards. Describes methods of quick determinations sufficiently true for the purpose required Ill. 1200 w. Jour Fr Inst—May, 1899. No. 27502 D.

Aluminum.

The Applications of Aluminum. (Sur les Applications de l'Aluminium.) Henri Moissan. A note to the French Academy, with analyses of commercial samples of aluminum and data as to its endurance under various conditions. 3000 w. Comptes Rendus—April 10, 1899. No. 27838 D.

The Applications of Aluminum. (Sur les Applications de l'Aluminium.) A. Ditte. A reply to the communication of M. Moissan. 1800 w. Comptes Rendus—April 17, 1899. No. 27846 D.

The Impurities in Aluminum. (Sur les Impuretés de l'Aluminium.) A. Minet. An examination of the influence of the method of producing aluminum upon the impurities contained in the resulting metal. 1800 w. Comptes Rendus—May 8, 1899. No. 27846D.

Bronze.

See Mechanical Engineering, Machine Works and Foundries.

Corundum.

The Corundum Deposits of Ontario. T. W. Gibson. An account of the discovery of the mineral in the eastern part of the province of Ontario, describing the deposits, and giving their value. 1700 w. Eng and Min Jour—April 29, 1899. No. 27368.

Fluor Spar.

Fluor Spar Deposits in Kentucky. Richard Moldenke. Describes this spar and states the localities where it is found,

and peculiarities of the deposits, the purposes for which it is used, etc. 2000 w. Ir Trd Rev—May 11, 1899. No. 27592.

Manganese.

The Manganese Mines of Brazil. (Les Mines de Manganese au Bresil.) Daniel Bellet. A general review of the deposits in Brazil, with data of costs of mining and transport. 2000 w. Revue Technique—April 25, 1899. No. 27807 D.

Petroleum.

Prospecting for Oil in an Untried Region. Arthur Lakes. How oil was found in Colorado, where there were no direct indications on the surface. 1700 w. Mines & Min—May, 1899. No. 27448 C.

Some Notes on the Petroleum Deposits of California. Harold W. Fairbanks. States the conditions under which petroleum occurs in California and which seem to differ from Prof. Orton's statements concerning eastern fields in respect to migration. 1200 w. Min & Sci Pr—May 20, 1899. No. 27776.

Quicksilver.

The Ohaeawai Quicksilver Deposits. André P. Griffiths. Read before the N. Z. Inst. of Min. Engs. Results of prospecting and mining operations, giving locality, geological features, deposits, their origin and formation and describing the furnaces. 4400 w. N. Z. Mines Rec—March 16, 1899. No. 27710 B.

Slate.

The New York Slate Industry. J. Nelson Nevius. Part first gives the location of the slate belt and illustrated description of some of the quarries. 2200 w. Eng & Min Jour—May 20, 1899. Serial. 1st part. No. 27674.

RAILWAY AFFAIRS

CONDUCTING TRANSPORTATION.

Accidents.

Train Accidents in the United States in March. Detailed list and classified summary. 3500 w. R R Gaz—May 12, 1899. No. 27585.

Claim Agents.

The Claim Agent and His Relation to the Safety of Employees. L. L. Gilbert. Abstract of a paper read before the St. Louis Ry. Club. On the attitude of their agents, the best way to settle claims, safety devices, inspection, etc. 1300 w. R R Gaz—May 19, 1899. No. 27671.

Loading.

The Loading of Long Structural Material. The latest revised form of the rules and regulations of the Master Car Builders' Assn. for the loading and carrying of structural material. Ill. 4000 w. Bridges—May, 1899. No. 27685 C.

Mileage.

The Michigan Mileage Case. Extracts from the opinion of the United States supreme court, with editorial comment. 4700 w. Ry Age—April 28. 1899. No. 27389.

FINANCIAL.

Russia.

Railroad Business in Russia in 1898. Reports the increase in mileage, total length of lines, projected lines, and other matters relating to the railroad interests. 1100 w. U. S. Cons Repts. No. 434—May 24. 1899. No. 27741D.

MOTIVE POWER AND EQUIPMENT.

Austria.

The Development of Locomotives and Cars in Austria. From the *Zeitung des Vereins*. Descriptive. 1400 w. R R Gaz—May 12, 1899. No. 27587.

Brasses.

See Mechanical Engineering, Machine Works and Foundries.

Coal Cars.

80,000-Pound, 35-Foot, Coal Cars. Drawings and description of a new design for drop-bottom coal cars of the gondola type. 1100 w. Am Eng & R R Jour—May, 1899. No. 25393 C.

Fast Runs.

Fast Runs on the Burlington. Summaries of two very fast runs made on this road on April 14 and 22, 1899. 400 w. Ry Age—April 28, 1899. No. 27390.

Foreign Practice.

The Impression of a Motive Power Man in a Trip Abroad. R. H. Soule. Prepared for the Texas Ry. Club. A record of observations that interested a motive power man during a trip to Russia and South Africa. Ill. 1800 w. R R Gaz—May 12, 1899. No. 27586.

Locomotive.

See Mechanical Engineering, Power Applications.

Locomotive Boiler.

The Wootten Boiler. S. M. Vauclain. Considers the origin, evolution, and advantages for high speed, for greater horse-

power, for inferior fuel. General discussion and illustrations. 920 w. N. Y. R R Club—April 20, 1899. No. 27663.

Locomotive Performance.

The Ton-Miles Per Hour. George S. Hodgins. Discusses the unsatisfactory method of appraising the performance of a locomotive by giving its number of car miles, and the more accurate method of using the ton-mile. 1600 w. Loc Engng—May, 1899. No. 27357 C.

Locomotives.

A Heavy Express Locomotive for the Lancashire & Yorkshire. J. Pearson Pattinson. Illustrations and dimensions of a powerful engine, with facts concerning it. 900 w. R R Gaz—May 19, 1899. No. 27672.

Amount and Distribution of Work in Building a Locomotive. Editorial discussion of an article by T. R. Browne, which is considered to contain much valuable information. 1700 w. Am Eng & R R Jour—May, 1899. No. 27398 C.

Compound Consolidation Locomotives for the Southern Pacific. Descriptive specification with engraving. 500 w. R R Gaz—May 5, 1899. No. 27497.

Consolidation and Mogul Locomotives. General dimensions and illustrated descriptions of compound consolidation, and simple mogul locomotives. 1000 w. Am Eng & R R Jour—May, 1899. No. 27395 C.

Express Passenger Locomotive for the French State Railways. General and detailed views, short description and leading particulars. 500 w. Engng—April 21, 1899. No. 27432 A.

Fast Passenger Locomotives of the Chicago and Northwestern Railway. Illustration and principal dimensions of new eight-wheel locomotives to be used in fast service between Chicago and Omaha. 900 w. R R Gaz—May 26, 1899. No. 27769.

Heavy Locomotives for the Lake Shore. Illustrated description of these new engines which are the heaviest yet put in service on this road. 900 w. Ry Age—April 28, 1899. No. 27391.

Heavy Passenger Locomotive for the Vandalia Line. Illustration general dimensions and description, with account of a run made April 21, with a train of five cars. 1000 w. Ry. & Engng Rey—May 20, 1899. No. 27727.

High-Speed Simple Passenger Locomotives. Clement F. Street. Abstract of a paper presented at the March meeting of Western Ry Club. Details regarding the locomotives used in the United States in high-speed passenger service. 2200 w. Eng News—May 4, 1899. No. 27464.

Locomotive Repairs and Renewals. R. Price-Williams. Calculations on the average life of a locomotive and the amounts necessary to maintain it in an efficient condition during that period. 1000 w. Engng—May 5, 1899. No. 27616 A.

New Coupled Express Engines on Great Western Railway. Charles Rous-Marten. Briefly reviews the types used for express running by this road, and describes the new engines known as the Badminton class, of which twenty have been built, giving report of runs. 1800 w. Engr, Lond—April 28, 1899. No. 27536 A.

Tank Engine for South Africa. Dimensions and illustrated description of one of six engines recently constructed for the Pretoria and Pietersburg Railway. 800 w. Engr, Lond—May 5, 1899. No. 27613 A.

The Midland's American Engines. Photograph and brief description of these engines, with extracts from a letter by Clement E. Stretton, in the *Leicester (Eng.) Daily Post* concerning the points wherein they differ from English locomotives. 800 w. Transport—May 5, 1899. No. 27632 A.

Vauclain Fast Passenger Compound Locomotives. Engraving, with the chief characteristics of the design. 700 w. Am Eng & R R Jour—May, 1899. No. 27392 C.

Speed.

The Atlantic City Flyer—Philadelphia & Reading Railway. H. H. Vaughan. An analysis of the performance of one of the engines of the Atlantic type on the fifty-minute run from Camden to Atlantic City. 1000 w. Am Eng & R R Jour—May, 1899. No. 27399 C.

Stacks.

A Chapter on Locomotive Stacks. A series of drawings showing the variety of designs of stacks covering the experience of the Union Pacific Ry. from 1864 to the present time. 600 w. Am Eng & R R Jour—May, 1899. No. 27309 C.

Trucks.

The Bogie Truck. Maurice Demoulin. An illustrated review of the different types of bogie trucks in use in the United States. The present number deals with freight car trucks. 2400 w. R R Car Jour—May, 1899. Serial. 1st part. No. 27558.

Train Resistance.

A Formula for Train Resistance. Henry Graftio. Gives some of the results secured abroad. 3900 w. St Ry Jour—May, 1899. No. 27452 D.

NEW PROJECTS.

Improvements.

Long Island Railroad Improvements. An illustrated account of improvements made and proposed, which will cost about

a million dollars. Includes a tunnel under the East River. 1000 w. R R Gaz—May 5, 1899. No. 27494.

Railroad Building.

New Railroad Building in 1898. Revised figures of the total mileage of new roads built in United States, Canada and Mexico. 3500 w. R R Gaz—May 26, 1899. No. 27771.

Railroad Improvements.

The Brooklyn Terminal Improvements and East River Tunnel of the Long Island R. R. Considers the plan of this road to furnish an all-rail route from the suburban towns on Long Island to the business centers of Brooklyn and Manhattan. Also editorial. Ill. 3800 w. Eng News—May 18, 1899. No. 27669.

Railway Location.

An Interesting Piece of Railway Location. Gives a contour map showing interesting work in the Gokteik gorge, on an extension of the Burma Ry. 900 w. Ry & Engng Rev—May 20, 1899. No. 27728.

Switzerland.

New Railway Projects in Switzerland. (Neue Schweizerische Eisenbahn Projekte.) R. Moser. A discussion of the plans for the extension of the Swiss Railways consequent upon the acquisition of the entire system by the government; with especial reference to the Weissenstein railway. 3000 w. Schweizerische Banzeitung—April 8, 1899. No. 27832 B.

Upper Burma.

The Mandalay-Kunlon Railway. E. Wynan Wagstaff. Deals with a portion of the line from the valley of the Irrawoddy to that of the Salween, now in process of construction. Map. 1400 w. Ind Engng—April 8, 1899. No. 27575 D.

PERMANENT WAY AND FIXTURES.

Albany Station.

New Union Passenger Station at Albany, N. Y. An illustrated general description of the new union passenger station now being built. 9000 w. Ry & Engng Rev—May 6, 1899. No. 27554.

Boston Station.

The Boston Southern Station. J. P. Coleman. Illustrates and describes the track facilities and interlocking which give this station the greatest traffic possibilities in the world. 3000 w. R R Gaz—May 12, 1899. No. 27584.

Concrete Masonry.

Concrete as a Railway Masonry. W. A. Rogers. A brief outline of railway concrete masonry, describing the main features in its construction. 2500 w. Wis Engr—May ,1899. No. 27660 D.

Construction.

Permanent-Way Construction. (Vom Eisenbahn-Oberbau.) H. Claus. With especial reference to the use of steel sleepers, and heavier rails, with data from the St. Gothard and the Liége-Limburg railways. 3000 w. Glaser's Annalen—April 15, 1899. No. 27847 D.

Omaha Stations.

The New Railway Stations at Omaha, Neb. Introductory account of the various projects for station improvement in this city, and illustrated description of the Burlington station. 2800 w. Eng News—May 4, 1899. No. 27462.

Road Bed.

The Conditions Existing Under Railway Sleepers. (Ueber die Vorgänge unter der Schwelle eines Eisenbahngleises.) A study of the action of the pressure on the sleepers upon the ballast beneath; with many illustrations. 4500 w. Glaser's Annalen—May 1, 1899. No. 27849 D.

St. Gothard.

The St. Gothard Railway. (Le Chemin de Fer du St. Gothard.) Jules Michel. Describing especially the permanent way, and the results of the reconstruction of portions with steel sleepers. 4000 w. Rev Gen de Chemins de Fer—May, 1899. No. 27811 F.

Signaling.

Block Signaling and Interlocking on the Chicago, St. Paul, Minneapolis & Omaha Ry. Describes the operation of the telegraph block system, the automatic signals and the interlocking plants. Ill. 2500 w. Eng News—May 25, 1899. No. 27754.

Block Signaling. J. P. Coleman. Illustrates and describes some modern methods used extensively in America, showing the advancement made on early practice. 7000 w. Wis Engr—May, 1899. No. 27656 D.

Electric Interlocking Apparatus. (Les Appareils de Vérouillage Electrique.) M. Bouvier. An illustrated description of the electrical signal apparatus used on the Paris-Lyons-Mediterranean Railway. 7500 w. 2 plates. Rev Gen des Chemins de Fer—May, 1899. No. 27810 F.

Interlocking Plant at Pacific Junction; Chicago, Milwaukee & St. Paul Ry. Illustrated description of a plant at a complicated junction. 900 w. Eng News—May 11, 1899. No. 27593.

Revolving Signal for Cabooses. Illustrates and describes an apparatus which has been in experimental use on the Chicago, Rock Island & Pacific, and on other roads. 600 w. Ry & Engng Rev—May 13, 1899. No. 27623.

The Relative Importance of Train Signalling Indications. J. Pigg. An explanation of the meanings of different indications, and their relative importance.

1400 w. Elec Eng, Lond—May 5, 1899. No. 27639 A.

The Track Circuit. C. C. Anthony. An explanation of the requirements and advantages of this system. 1800. Elec Wld & Elec Engr—April 29, 1899. No. 27363.

Switch Stand.

The Flickinger Switch Stand, L. S. & M. S. Ry. Illustrates and describes a switch stand in which the safety device is operated by the action of the switch stand itself. 900 w. Ry & Engng Rev—May 6, 1899. No. 27555.

Tunis.

The Railway from Sfax to Gafsa, Tunis. (Le Chemin de Fer de Sfax à Gafsa.) With map of the route, elevation of the track-laying machinery, and views of the terminals. 1500 w. Génie Civil—April 22, 1899. No. 27803 D.

TRAFFIC.

Coal Traffic.

The Great Central New Coal Traffic Arrangements. An account of the special arrangements for dealing with the universal traffic from the Midlands and North of England since the opening of this line to London. Ill. 1100 w. Ir & Coal Trds Rev—May 5, 1899. No. 27605 A.

Rates.

Home and Foreign Railway Rates for Goods Traffic. B. H. Thwaite. Summary of an address delivered before the London Chamber of Commerce. Advocating the low freight policy. 1500 w. Prac Engr—April 28, 1899. No. 27533. A.

STREET AND ELECTRIC TRAMWAYS

Accounting.

Accounting System of the Omaha & Council Bluffs Railway & Bridge Co. Describes the monthly report and comparative statement blanks designed by W. S. Dimmock. 3000 w. St Ry Rev—May 15, 1899. No. 27730 C.

Boston Elevated.

The Boston Elevated Railway. Illustrated description and general information. 3800 w. Eng News—May 11, 1899. No. 27597.

Brake.

Electric Brake for Trailers. (Elektrische Betriebs-und Nothbremse für Anhängewagen Elektriser Bahnen.) Describing a form of brake for trailing cars on electric tramways; a magnet holds the brake out of contact unless the coupling breaks. 1000 w. Elektrotech Zeitschr—May 4, 1899. No. 27876 B.

Construction.

Overhead Line Construction. Albert B. Herrick. Relates to the selection and erection of apparatus and methods of construction. Ill. 4000 w. St Ry Jour—May, 1899. Serial 1st part. No. 27450 D.

Contact System.

The Electric Tramways of Tours. (Tramways Electriques de Tours.) E. Dieudonne. An illustrated description of the Diatto system, as installed at Tours, France. The current is conveyed to the cars by a pin-contact system, from an underground conductor, there being no slot in the street. 2000 w. Revue Technique—April 25, 1899. No. 27806 D.

The Surface Contact System of the Union-Elektricitatsgellschaft. (Das Oberflachenkontaktsystem der Union-Elektricitatsgellschaft.) M. Kubierschky. A general description of the General Electric Company's system as applied in Germany. 4500 w. Elektrotech Zeitschr—April 27, 1899. No. 27873 B.

Electrical Machinery.

The Electrical Inspection of Street Car Equipments. Albert B. Herrick. Describes means by which troubles are detected and located. Ill. 4000 w. Jour Fr Inst—May, 1899. No. 27501 D.

Electric Railways.

Right of Way, Grades and Grade Crossings of Electric Railways. Editorial discussion of the litigation over the proposed purchase of a right of way for a portion of the new Aurora & Geneva Electric Ry. in Illinois, giving particulars of the case. 5000 w. Eng News—May 18, 1899. No. 27670.

The Omaha & Council Bluffs Railway & Bridge Co. Illustrates and describes a railway equipped in 1888. 3500 w. St Ry Rev—May 15, 1899. No. 27729 C.

Electric Traction.

The Influence of Electricity Upon Railway Locomotion. B. H. Thwaite. With especial reference to the practicability of applying electric traction to underground and main line railway service where steam locomotives are now in use. 4000 w. Engineering Magazine—June, 1899. No. 27894 B.

Indispensable Accessories of Electric Traction. Henry E. P. Cottrell. Part first illustrates and discusses the various types of modern electric car trucks, and the requirements they must fulfill. 3400 w. Elec Rev, Lond—April 28, 1899. Serial. 1st part. No.27528 A.

Electrolysis.

Electrolysis as an Unsolved Municipal

Problem. H. S. Wynkoop. Extract from a paper read before the Engs'. Club of Brooklyn. N. Y., giving a report of an investigation made of the Brooklyn water mains. 1800 w. Elec Wld & Elec Engr —April 29, 1899. ' No. 27365.

Gas Engine Plant.

Test of an Electric Railway Power Plant Driven by Gas Engines. E. Hill, Jr., and J. C. Brocksmith. Test made for a graduating thesis of a novel plant at Huntington, Long Island. 1600 w. Sib Jour of Engng—May, 1899. No. 27762 C.

Indianapolis.

The Indianapolis Street Railway Franchise. A review of a 34-year franchise for which the company pays $1,160,000 cash and promises to spend over $1,000,000 in improvements of track and equipment under the direction of the local board of public improvements. 1500 w. Eng Rec—May 13, 1899. No. 27576.

Interurban.

Analysis of the Operation of an Interurban Railway. A study of the Lorain & Cleveland Railway Company's line, which has a length of 18.5 miles. Ill. 6500 w. St Ry Jour May, 1899. No. 27-449 D.

Large Interurban Electric Railway in Southwestern Missouri. An illustrated account of the road connecting Carthage, Carterville. Webb City and Joplin. 2800 w. St Ry Jour—May, 1899. No. 27451 D.

Jungfrau.

The Jungfrau Railway. (Le Chemin de Fer de la Jungfrau.) H. Martin. A very complete account of this important Swiss mountain road, with details of the hydraulic and electric plant and of the three-phase system adopted; also of the road structure, tunneling, etc., and photographs of the present condition of the work. Two articles, two plates. 7500 w. Génie Civil—April 22, 29, 1899. No. 27-802 each D.

Locomotive.

See Electrical Engineering, Power Applications.

Motormen.

School for Motormen. Describes the training methods in use by the Metropolitan Street Railway Co., of New York. Ill. 1200 w. St Ry Rev—May 15, 1899. No. 27732 C .

Mountain Road.

The Electric Railway between Stansstadt and Engelberg.) Die Elektrische Bahn Stansstadt-Engelberg.) A very full account of this important Swiss mountain road. The three-phase system is used and a ladder-rack between the rails. 3000 w. Zeitschr d Ver Deutscher Ing—April 15-1899. No. 27815 D.

The Stansstadt-Engelberg Electric Railway. (Die Elektrische Bahn Stansstadt-Engelberg. A description, with map and many illustrations, of the new electric rack-railway from Stansstadt, on the Lake of Lucerne to Engelberg, nearly 2000 feet above, at a distance of about 14 miles. Two articles. 3500 w. Schweizerische Bauzeitung—April 15, 22, 1899. No. 27833 each B.

Power Calculation.

An Analytical and Graphical Method of Computing the Resistance to Starting and Stopping on Electric Tramways. (Eine Analytische und Graphische Methode zur Berechnung von Anfahr-und Bremswiderstanden für Elektrische Eisenbahnen.) F. Erens. An elaborate mathematical analysis, showing that rational methods can be used in practice instead of the empirical ones formerly in vogue. 6000 w. Elektrotech Zeitschr—April 20, 1899. No. 27-872 B.

Rolling Stock.

Maintenance and Repair of Rolling Stock. J. W. Greer. On the management of the mechanical department and the wisdom of letting employees understand that there is considerable on the expense side of the ledger. 1800 w. St Ry Rev —May 15, 1899. No. 27731 C.

Signaling.

An Automatic Block System for Single-Track Electric Railways. Illustrates, and describes a system which has been in successful operation on a branch of the Lowell & Suburban Ry. in Massachusetts. and has just been installed on the main road. 1600 w. Eng News—May 25, 1899. No. 27756.

Tramways.

The Potteries Electric Tramway. Illustrated description of an extensive system of tramways in England, which will now have electric service. 2500. Elec Eng. Lond—May 19, 1899. No. 27795 A.

Tramway Conversion.

The Conversion of the Zurich Tramway for Electric Driving. (Der Umbau der Zürcher Pferdebahn fur Elektrischen Betrieb.) P. Schenker. With details of methods of drainage, track-laying, bonding, etc. Serial. Part 1. 2500 w. Schweizerische Bauzeitung—May 6, 1899. No. 27835 B.